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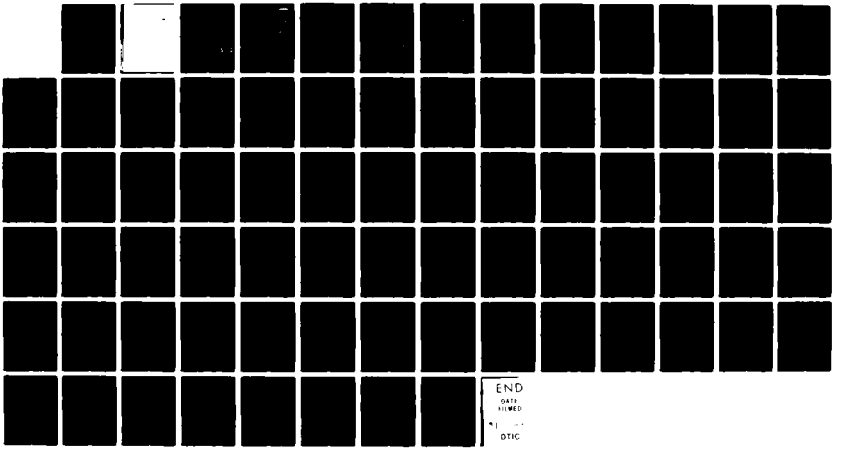

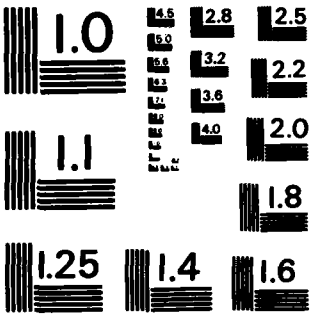

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PRODUCTIVITY IMPROVEMENT IN A PURCHASE DIVISION: EVALUATION OF A PERFORMANCE CONTINGENT REWARD SYSTEM (PCRS)

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Performance contingent reward systems (PCRSs) were developed for small purchase buyers and supply clerks in a purchase division of a naval shipyard supply department. The rewards were financial incentives provided to individual civil service employees performing above standard. Description of the system and an evaluation of its effectiveness in increasing productivity and saving costs are provided. Results showed that systems increased productivity substantially and were cost effective.

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FOREWORD

This project was conducted in support of exploratory development task area ZF63521-018-03.03 (Productivity Measurement Techniques).

This report is one in a series concerned with the development, exploration, and generalization of a technique to increase individual motivation and productivity, which relies on applying behavioral science principles in what is termed a performance contingent reward system (PCRS). It describes the effectiveness of a PCRS as applied to a group of small purchase buyers and supply clerks in a naval shipyard.

The information herein is intended for the use of Navy and federal managers and supervisors concerned with improving the motivation and productivity of their organizations.

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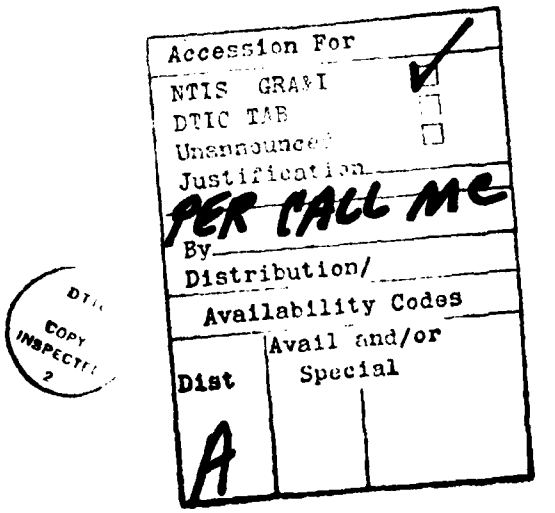

SUMMARY

Problem

Productivity growth in the U.S. has become a national priority. Improvement of productivity in the Navy, as well as in other government agencies, is part of this nationwide concern. Sound, effective, and proven strategies for accomplishing this improvement need to be developed and documented.

Purpose

The purpose of this effort was to evaluate a performance contingent reward system (PCRS) as applied in a purchase division of a naval shipyard supply department. The system was developed to extend the findings of previous research and development to small purchase buyers and supply clerks. The evaluation was conducted to determine whether (1) a PCRS would improve individual productivity, (2) such an improvement would be cost-effective, and (3) participants would desire the PCRS to continue.

Approach

Actual productivity and cost data from two periods--a 17-week "base" period prior to PCRS implementation and a 17-week "trial" period 7 months after the program had been implemented--were compared. Also, an anonymous questionnaire was administered 1 year after PCRS implementation (1) to all available program participants, (2) a random sample of department nonparticipants, and (3) program managers and supervisors. Responses were analyzed for statistical significance and financial and economic impact.

Results

Significant differences between base and trial periods were found for all measures of productivity. Based on an overall 26 percent increase in productivity, production-cost savings realized by the PCRS during the 17-week trial period exceeded $14,[illegible]. A financial and economic analysis (F&EA) indicated that total PCRS setup and development costs incurred by the shipyard would be recaptured in approximately 1 year's time. Furthermore, a comparative evaluation of the base period (June-September 1979) with the trial period (June-September 1980) demonstrated that production-cost savings realized with the program had actually enhanced production effectiveness. The major factors analyzed were the level of production (requisitions processed), productivity (requisitions per labor hour), and process effectiveness (as measured separately by the size of workload backlog, procurement average lead time, and by the overtime required).

Production based entirely on test-site parameters indicated net cost savings to the government for 1-, 2-, 3-, and 5-year periods in excess of $[illegible]K, $127K, $[illegible], and $[illegible], respectively. An alternative cost effectiveness evaluation method determined a net present value (NPV) for the program over a 5-year period of $[illegible]K, when using a discount rate of 10 percent. In addition, the benefit-cost ratio (B/C) rated at [illegible] strongly pointed to the success of the program.

If the PCRS were subsequently spread to the approximately [illegible] small purchase buyers and supply clerks in the Navy supply community with the same degree of success, the projections of cost savings would expand to [illegible] for future periods. Furthermore, a large majority of the participants [illegible]

positive about almost all of the program's features. Of those [illegible] naire, 73 percent were in favor in continuing the program, while 13 [illegible] discontinue it and 13 percent were undecided.

Conclusion

The results support the hypothesis that a PCRS can increase [illegible] among small purchase buyers and supply clerks in a [illegible] effectiveness and the approval of the work force. The value of such a [illegible] attractive. It is likely that a very large number of Navy white collar [illegible] variety of jobs could be participants in PCRS programs. Difficulties in [illegible] maintaining the effectiveness of such programs by local management [illegible] need to be carefully considered and require continued research and development.

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Problem

The rate of productivity growth (annual percent increase) in the United States is now lower than those in Japan, West Germany, France, Italy, and Canada (Sheils, Thomas, Abraham, & Lubenow, 1980, p. 52). The United States must find ways to increase its rate of productivity improvement if it is to maintain its economic position in the world and its standard of living, as well as to control inflation.

Government operations are a significant part of the problem and must be part of any solution. The public sector has become such a large proportion of the total economy (fully one-third of the gross national product (GNP)) that it has become a substantial drag on the rest of the economy. The clear implication is that the resources available to operate government are rapidly shrinking. If government services are to be maintained or their erosion minimized, it must be through productivity improvement. This would not only increase the public sector contribution to national productivity but also free scarce resources to help the private sector find ways to improve its productivity.

Productivity improvement has become a national priority. Thus, sound, effective, and proven strategies for improving productivity need to be developed and documented. Some would argue that the solution to our productivity problems lie in capital investments to improve technology. Although there is little doubt that substantial gains can be made through advanced technology, most behavioral scientists recognize that all systems, whether using new or old technology, depend upon a motivated work force for efficient operation. One method developed to increase the motivation and productivity of federal workers is a performance contingent reward system (PCRS), which attempts to tie financial rewards to objective measures of productivity. Initial tests of such a system using key entry operators resulted in substantial improvements in productivity. As a result, there were productivity improvements of between 11 and 50 percent at the different sites using the system, resulting in financial savings estimated to exceed $1,000,000 over a 5-year period. In addition, it led to a Exemplary Practice award in the federal government award system. (For more complete description of this effort, see Bretton, Dockstader, Nebeker, & Shumate, 1978; Shumate, Dockstader, & Nebeker, 1978; Nebeker & Nocella, 1979; Dockstader, Nebeker, Nocella & Shumate, 1980; Shumate, Dockstader, & Nebeker, 1981; and Joyce, 1981). The success of the program was a major factor influencing the Naval Civilian Personnel Command (NCPC) to revise its Navy personnel instructions on incentive award practices.[1] The revisions were intended to encourage agencies and organizations to use a PCRS (called a Productivity Incentive Award Plan in OPNAV guidance) where possible.

These results, while impressive, have been questioned as to their generalizability. Some critics suggest that the benefits of such a system will be limited to simple, repetitive tasks performed by low level employees. Whether PCRSs can be generalized beyond this limited group of tasks and employees needs to be demonstrated.

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[1]Naval Civilian Personnel Instruction 451 dated 29 April 1982.

Purpose

This research and development was undertaken to determine whether PCRSs could be generalized to tasks that are substantially more complex than those performed by key entry operators and that are performed by higher level employees. This report describes the development of a PCRS for small purchase buyers and supply clerks in a naval shipyard and provides an evaluation of this system to determine whether (1) a PCRS can increase the productivity of these personnel, (2) such an increase would be cost effective, and (3) employees, supervisors, and management will be satisfied with the program. Results should be of interest to both military and civilian managers in the Navy community, as well as to managers in other federal agencies and in state, local, and private sector organizations.

Background

Defining Productivity

As the interest in productivity has increased, it has become clear that many people are confused about just what productivity is, how it should be measured, and how it can be improved. The key to understanding and influencing any variable is first being able to define it.

Productivity and many other terms are sometimes used synonymously. Performance, effectiveness, efficiency, achievement, accomplishment, and behavior have all been used as surrogate terms for productivity. Productivity, as used in this report, is very specifically defined as the ratio of goods or services produced (output) to the resources used in their production (input) as shown in the following equation (Greenberg, 1973; Siegel, 1980):

$$\text{Productivity} = \frac{\text{Measured Output}}{\text{Measured Input}} \quad (1)$$

The simplicity of this equation is deceiving, since the actual measurement of the outputs and inputs can often be complicated and confusing.

Ignoring the complications for the moment, the measurable output of small purchase buyers and clerks can be defined in terms of the number of requisitions and orders processed. The measured input is predominately the number of labor hours used to produce these outputs. So, for a group of small purchase buyers and clerks, productivity can be defined as either the number of requisitions or orders processed per labor hour. To measure productivity in such a way as to allow comparisons between individuals or groups, more complex measures need to be developed. A discussion of the issues, concepts, and methods for developing these types of productivity measures, sensitive to both quantity and quality considerations, is provided in Appendix A.

Improving Productivity

Having defined productivity, the next question is how it might be increased. A number of factors are considered as important in determining an individual's or a group's productivity. These factors can be divided into two broad categories: (1) those that affect an individual's ability to be productive, and (2) those that affect an individual's motivation to be productive. Although both categories of factors need to be considered in any program designed to improve productivity, ability factors are often emphasized and motivation factors, ignored. Appendix B provides a more complete discussion of the determinants of productivity than can be presented here, including a model for classifying

different techniques available for improving productivity and a discussion of the relative importance of techniques to improve individual motivation.

If productivity is to be improved through increased motivation, it is necessary to understand the factors that affect motivation. Expectancy theory (Vroom, 1964; Mitchell, 1974; Nebeker & Moy, 1976; Ilgen, Nebeker, & Pritchard, 1981) provides a model of motivation that is extremely useful in understanding what needs to be changed to increase worker motivation. Based upon expectancy theory, worker motivation is determined by three perceptions or beliefs held by the worker: (1) the perception of how much effort is required to reach alternative levels of performance, (2) the perception that the alternative performance levels will be rewarded or punished, and (3) the perceived value that individuals place on those rewards or punishments. Individuals will be motivated to be highly productive if and only if they (1) perceive their effort will result in high productivity, (2) perceive that high productivity rather than low productivity will be rewarded and not punished, and (3) value those rewards. If any of these variables are low, motivation to be a high producer will be severely restricted.

Many things within an organization can influence workers' perceptions or beliefs about these variables, such as the organization's reward policies and practices, the difficulty of the tasks, and the peer or work-group responses to productivity. The primary aim of this research and development effort was to change worker perceptions so that they would believe that high productivity would be likely to result in their receiving valued rewards. It is assumed that, if workers believe increased productivity is likely to result in valued rewards, they will freely chose to improve their productivity. A PCRS is an attempt to apply the theoretical principles of expectancy theory to the practical problems of employee motivation toward improved productivity.

APPROACH

Organization Selection and Mission

The selection of a site to do follow-on research to test the generalizability of a PCRS required that the employees involved be tasked with jobs that were less repetitive (longer cycle times), more difficult to measure, resulted in better pay, and had higher skill or education demands than those performed by key entry operators. With these requirements in mind, it was decided to develop a PCRS for small purchase buyers and supply clerks employed in the Purchase Division of the Supply Department in a naval shipyard. Taking the position that a PCRS that follows sound behavioral principles will increase employee productivity and be perceived as beneficial by the workers, the following hypotheses were generated:

1. A PCRS will increase labor productivity of small purchase buyers and supply clerks will increase labor productivity.

2. A PCRS will reduce unit production costs for small purchase buyers and supply clerks.

3. PCRS participants will favor continuing the program.

The mission of a naval shipyard is to overhaul and repair Navy surface ships and submarines powered by both conventional and nuclear power plants. A supply department supports the shipyard's mission by acquiring and staging the material required to effect

overhauls and repairs. A purchase division is responsible for acquiring all material that cannot be obtained through the federal supply system; that is, all material that must be purchased with local purchase authority rather than obtained from the General Services Administration (GSA), DoD, or Navy sources.

The shipyard Purchase Division is divided into three branches: (1) Contracts (Code 531), (2) Small Purchase (Code 532), and (3) Support Services (Code 533). At the time of the research, the Contracts Branch handled all purchases that exceeded $10,000 in cost, the Small Purchase Branch made purchases under $10,000 in cost and placed orders against delivery-order-type contracts, and the Support Services Branch provided clerical support (typing, filing, etc.) for the other two branches. The actual program developed in the Purchase Division encompassed only the Small Purchase and Support Services Branches. The Contract Branch was excluded because of the small number of employees involved (five at the time of the study) and the difficulty in obtaining data on which to develop productivity standards for these employees.

Subjects

The subjects were 10 small purchase buyers and 12 supply clerks. During the course of program development and evaluation (1 year and 9 months), a number of personnel changes were observed, as would be expected. Four of the small purchase buyers and 10 of the supply clerks left their branches between the base and trial periods. Of these, three buyers and three clerks left to take promotions within the Supply Department. This turnover created a rather interesting problem for evaluating the effects of the program, particularly in the case of the buyers. Since none of the new buyers coming into the branches had any previous buying experience, they were likely to be substantially less productive during their training period than were the highly experienced buyers they had replaced. Supervisory expectations were that it required about 2 years for a new buyer to become fully proficient. As a result, it was necessary to develop a method for adjusting performance to equalize the experience of buyers in the program's base and trial periods. This procedure is described in Appendix C. It is interesting to note that the supervisor's judgment about the length of time needed to become proficient was confirmed.

It was not necessary to develop a method for adjusting clerk performance since the effect of their experience on productivity was not as important. Further, at the time of the trial period, almost all of the new clerks had been on the job long enough to minimize any effects due to inexperience.

Measures

A variety of measures were used to evaluate the PCRS. These measures are described below.

1. Employee Output. In this division, the principle output measure for both small purchase buyers and supply clerks is a completed requisition. While the actual steps taken by the two groups to process a requisition are different, involving different activities and skills (e.g., buyers are responsible for requesting quotations of price and delivery dates of venders; and clerks, for typing and filing), the ultimate aim of their activities is completion of a purchase requisition. Thus, the number of requisitions processed by these two groups is the output measure of interest. To determine work standards (discussed below), it was necessary to break this output down into its component activities. For general evaluation of the PCRS, however, the utlimate purpose for the division (processing requisitions) was the appropriate unit of output measurement.

2. Employee Input. Labor hours expended to process requisitions was the measure of employee input to productivity. The value of an employee's labor hour, however, is not necessarily equivalent across time periods. For example, an experienced employee would normally be more efficient than an inexperienced employee in some jobs. This was true for the small purchase buyers in this organization. Therefore, if the buyer's average level of experience changed over time, it could have a biasing effect on the measurement of productivity change due to the PCRS. As indicated previously, this potential problem was corrected for this evaluation by correcting the labor hours based on length of experience. A second potential problem with labor hours as a measure of input is that some labor hours cost more than others. Any overtime hours cost the organization substantially more than regular hours. This problem can be overcome by simply recording the number of hours expended in overtime to preserve their visibility. A final problem in measuring labor hours is the use of annual and sick leave. Because these hours are a part of cost considerations in the form of employee benefits (called acceleration), they also need to be identified. The measurement of labor hours then simply becomes the regular and overtime hours expended on the job by the small purchase buyers and supply clerks less all annual and sick leave.

3. Backlog. The backlog counts were simply the number of uncompleted requisitions on hand at the end of each week. Only small purchase buyers had backlog measured and monitored on a regular basis in the division. Some backlog is desirable (as a workload smoothing device) and some is necessary to maintain efficiency. For example, a small purchase buyer often requests information from vendors before making a purchase. Allowing a period of time for the vendor to provide the information before a closing date gives the vendor time to gather the information and formally respond. Without a backlog of work, the buyer would be idle while awaiting the reply. Based on typical closing dates, it was determined that each buyer needed to have a minimum of 230 requisitions in process or backlog to ensure no idle time. On the other hand, too much backlog would delay the timely delivery of material to the shipyard.

4. Procurement Average Lead-time. The procurement average lead time (PALT) was the average number of days that a requisition was in the hands of a buyer before it was purchased. Obviously, the shorter the PALT, the more responsive the buyer was to the requester.

5. Employee Satisfaction. Employee satisfaction was assessed by a short questionnaire (38 items) administered 1 year after the PCRS had been in effect. The instrument used, which was specifically designed for this evaluation, was intended to measure employee satisfaction with various components of the program and support for program continuation. It was administered by an individual not associated with the program or the Supply Department to protect the anonymity of all respondents. Respondents indicated their agreement or disagreement to positively and negatively worded items on a 5-point Likert-type scale.

PCRS System Design

Fundamental to most wage and salary systems is the concept that fair market compensation should be paid to employees in exchange for what is considered to be a fair amount of quality work. In most cases, compensation is considered to be pay and benefits; and quality work, as output that meets quality requirements.

What happens, though, when an individual or group exceeds productivity expectations? A PCRS provides a means to share the benefits of increased productivity with those responsible for the additional work output. Provision for these awards can be found in the incentive award program (Chapter 451 of the Federal Personnel Manual) of the federal government. An innovative use of this provision was developed so that productivity can be compared with what is expected of employees, the amount of an award earned, if any, can be computed, and incentive awards can be paid on a recurring basis. In addition, the program attempts to minimize any negative consequence (e.g., reduction in force (RIF)) that might occur when individuals improve productivity by securing a promise from management not to RIF employee or raise standards as a result of an increase in productivity.

Development of Standards

An important element in a PCRS is determining what level of work productivity is expected of employees. This involves determining how long it should take an employee to complete each unit of work. Such expectations are referred to as productivity standards. Since a PCRS' success often depends on the quality of the standards chosen, care should be exercised in developing such standards (see Appendix A for a more complete description of the problems involved).

Fairness

If standards are to have their desired impact on motivation, they must be perceived as fair and attainable; that is, an individual must believe the standards can be reached or exceeded and that the effort required to do so is not excessive. If he or she does not believe this, any rewards assocciated with performance above standard are likely to be ineffective. A variety of methods can be used to develop standards, including such traditional approaches as method-time-measurement techniques, predetermined time methods, work sampling, historical records, stop watch methods, and expert estimation (Barnes, 1980; Nebeker & Nocella, 1979). While some of these methods are more objective than others, they all use expert judgment to some degree. One's choice among them depends upon the nature of the work itself and the degree to which workers accept the method as a valid way of generating standards.

Complexity

The more varied the length of time required to complete tasks, the more necessary it is to develop multiple standards that reflect this variability (see Appendix A). Workers are not likely to accept general historical performance averages as fair, especially when there is also variability in the difficulty of the tasks performed by different people and/or in the difficulty over time of performing the different tasks by the same person. In either or both cases, it is necessary to develop standards that reflect variations in task difficulty. With both the small purchase buyers and the supply clerks, it was apparent that all purchase actions and typing jobs were not equal. There were both between-individual and across-time differences in the average difficulty and complexity of required actions; that is, some individuals worked on more difficult tasks than did others and individuals worked on more difficult tasks on some days than on other days. If standards were to be judged as fair, they would have to consider these differences.

Earned and Expended Hours

Providing a means for comparing the productivity of individuals doing different mixes of easy and difficult work is an important function of standards. As discussed in Appendix A, one approach to doing this involves determining an expected or "standard" time for a qualified worker of required skill to complete one unit of a particular product or output using available tools and procedures when working at a normal pace (Barnes, 1980). Then, with each completion of that product or output, a worker "earns" the standard time for that output, regardless of his or her actual time. This index of completed work (output) is called earned hours. By itself, earned hours is not an index of productivity, because it measures only the "output" portion of the productivity "output to input" ratio. An appropriate input index is called expended hours; that is, the time actually spent in completing the output. Earned hours divided by expended hours is an appropriate index of individual labor productivity, and it is the one used in the PCRS.

Methods Used to Establish Earned Hour Standards

There are a number of different ways to establish standards, each with its strengths and weaknesses. It is fair to say that no single method is clearly the best (Fein, 1974). Thus, where possible, more than one method should be used to compensate for weaknesses in any particular method.

The establishment of standards for small purchase buyers and supply clerks began by identifying the actual outputs and any existing standards for these outputs. It was determined that completed purchase actions, necessary modifications, required correspondence, and all associated typing were the important measurable outputs. The only standards that could be found for these outputs came from a work sampling study conducted in the Purchase Division during 1971-72. The study was conducted by the department's Management Analysis Branch as part of the Defense Integrated Management Engineering Systems (DIMES) program. Although there had been changes in the tasks and equipment used in the division since the time of study, a number of the standards developed were useful as benchmarks for comparison purposes. Standards for buyer actions and clerk typing were established as outlined below.

Small Purchase Buyer Standards

One important aspect of the tasks performed by the small purchase buyers not considered by the DIMES study was the variability in the difficulty of different types of purchases or "buys" and the time required to complete them. A further complication was that the mix of difficult and easy tasks changed over time for the buyers. Based on initial work, it became apparent that, if a PCRS were to be implemented, standards would have to be developed that would allow one buy to be compared to another. As a result, buyers and occasions could be compared.

The reason the buyers' work varied in difficulty was because different types of buys required different actions; the more actions required, the more time required to complete a buy. Undertanding this fact made it possible to determine what characteristics of buys were statistically associated with more actions and, therefore, greater time requirements. The statistical analysis procedure used is called multiple regression (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975). As applied to this problem, multiple regression solves for the "weight" of each purchase characteristic in determining the total time required to complete the order. The greater the effect the presence or absence of a characteristic had on the time taken to complete the order, the greater the weight for that

characteristic. This application of multiple regression is similar to that used to establish standards for key entry operators (Nebeker & Nocella, 1979). In the present application, over 1,400 different orders were analyzed to determine the weights of characteristics. Based on results of this analysis, four attributes were selected as being important in determining the time required to complete an order:

1. Whether or not the order was $500 or more.
2. Whether or not the order required competition among vendors.
3. Whether or not the order required special quality assurance processing.
4. Whether or not the order required special processing for material used in nuclear-powered ships.

By determining the relative weights of these characteristics, specific values could be substituted in the following regression equation to determine the length of time that a buyer should take to complete a specific order:

$$E = K + W_1 A_1 + W_2 A_2 + W_3 A_3 + W_4 A_4 \quad (2)$$

where

E = Hours expected to complete the order,

K = A constant time allowed for all orders,

W_1 = Weight of attribute 1 (cost $500 or more) in determining expected hours,

A_1 = Presence or absence of attribute 1 (1.0),

W_2 = Weight of attribute 2 (competition required) in determining expected hours,

A_2 = Presence or absence of attribute 2 (1.0),

W_3 = Weight of attribute 3 (quality assurance processing required) in determining expected hours,

A_3 = Presence or absence of attribute 3 (1.0),

W_4 = Weight of attribute 4 (nuclear processing required) in determining expected hours, and

A_4 = Presence or absence of attribute 4 (1.0).

Table 1 provides a list of all order types observed with some example time standards for those with one requisition and those with ten requisitions. The "Hours Earned" for each type of order differ, depending on the number of requisitions included; that is, the earned hours increase proportional to the number of requisitions.[2] Based on equation 2, the actual times were computed as follows:

$$E = .858 + .108A_1 + .222A_2 + .656A_3 + .107A_4.$$

[2]A bonus was added to the time standard for each requisition on each order as an incentive to encourage combining requisitions whenever possible. The amount of time added for each requisition was 2.5 percent if competition was not required and 5 percent if competition was required. The average order included approximately 2.5 requisitions.

Table 1

Standard Times for Different Types of Orders Handled by Small Purchase Buyers

Type No.	Attribute 1 Cost $500 or More	2 Competition Required	3 Quality[a] Assurance Processing Required	4 Nuclear[b] Processing Required	Standard Hours Earned: Number of Requisitions on Order 1	10
1	—	—	—	—	.879	1.072
2	—	—	—	X	.989	1.206
3	X	—	—	—	.990	1.208
4	X	—	—	X	1.100	1.341
5	—	X	—	—	1.113	1.358
6	—	X	—	X	1.140	1.710
7	X	X	—	—	1.254	1.791
8	X	X	—	X	1.366	1.952
9	—	—	X	—	1.552	1.892
10	X	—	X	—	1.663	2.026
11	—	X	X	—	1.829	2.613
12	X	X	X	—	1.942	2.775

Note. Standard times were also established for preparing a modification to a purchase order and preparing correspondence to a vendor (.3 hours each).

[a]Project target, target level-I, subsafe, or equivalent quality inspection required.

[b]Nontarget I and II, material certification required.

The standard times computed for various types of orders were compared with supervisor and employee estimates, past performance, and the general standards reported in the DIMES study to see if the standards had any obvious anomalies. Ultimately, the appropriateness of standards was determined using three criteria:

1. Were the relative individual standard times consistent with supervisor estimates, previous time data, and the numbers of actions required?

2. Were past individual performances such that at least 30 percent of the buyers had already reached standard? This percentage was chosen to ensure that the majority of buyers could attain the standards with a small increase in performance.

3. When these two criteria were satisfied, did management agree that the standards were reasonable?

Once these criteria were met, the standards were implemented.

Supply Clerk Standards

Since a large majority of the tasks performed by the supply clerks was very similar to those performed when the DIMES study was conducted, the standard times developed then were used as benchmarks for determining earned hours. The old time standards needed only to be updated and adjusted by adding new task categories and comparing the old times with the new supervisor and employee time estimates and performance trends. Observed differences could generally be resolved by identifying new equipment (e.g., IBM Mag Card typewriters) or new procedures (e.g., additional clauses being typed on the orders) now being used for the tasks.

For tasks not included in the DIMES study, standard times were interpolated from established allowances based on similarity. For example, if a new task required the same amount and kind of typing or copyng, it was given a proportionately greater allowance. Additional adjustments were made to allow for differences in the typewriters used in the division. The amount of the adjustment was based on differences in machine performance as reported by the IBM Corporation Office Products Division in Typewriter Performance Comparisons, OPD ADVFORM No. G540-3036. Finally, additional time was allowed on the tasks requiring typing of item descriptions based on the number of requisitions or line items typed and whether the task required special quality assurance or nuclear processing.

As with the buyer standards, the acceptability of the supply clerk standards was judged by comparing them with previous estimates and determining whether 30 percent of the qualified staff had been able to meet them. The final standards are presented in Table 2.

Method for Paying Incentive Awards

Productive Efficiency Report (PER)

The primary objective of a PCRS is to tie an incentive award with performance as directly as possible. Thus, the Productive Efficiency Report (PER), a computer-generated weekly printout of individual employee productivity, was developed to bridge the gap between an individual's performance and the actual receipt of a monetary reward that reflects the value of that performance. The senior author of this report developed the logic for the programs required to produce the PER, and the programming branch, Management Engineering and Information Office (Code 140), coded the programs.

The PER for the Small Purchase Branch provides the following information (see Figure 1).

1. BRANCH CODE--Identifies the specific branch in the Purchase Division to which the report applies.

2. IND--Individuals are identified by their initials or two letters of their choice if two people have the same initials.

3. JML RECD--Number of requisitions received for the week.

Table 2

Standard Times for Supply Clerk Tasks

Typing Task Type	Applicable Notations[a]	Standard Time (Hours)
V--Information for bids (IFB)	1, 2, 4	4.510
R--Request for proposals (RFP)	1, 2, 4	3.940
C--Contract	1, 4	2.440
D--Indefinite contract	1, 4	2.684
K--Form 26	4	.740
N--Modification of contract	3	.574
Q--Request for quotation (RFQ)	1, 2, 3	.361
P--Purchase order (PO)	1, 3	.410
M--Modification of PO	3	.410
W--Forms DD1149 and DD448	1, 3	.410
X--RFQ sent via telex	1	.361
H--Miscellaneous correspondence	--	.322
S--Resent RFQ	--	.283
T--Tracer	--	.244

[a]Notations defined as follows:

1. .0125 hours added for each requisition over 1 included in the typing.

2. If the quality assurance (QA) required is level 1 or equivalent, 10 percent is added to time; if QA required is nuclear target, 15 percent is added; if QA required is nontarget I and II, 12 percent is added.

3. If IBM electronic typewriter is used, time is reduced by 5 percent; if IBM standard typewriter is used, 5 percent is added.

4. Tasks performed only on the IBM Mag Card typewriter.

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BRANCH CODE 532 IND	JML RECD	JML BUY	NO. ORDR	NO. MOD	NO. T&C	BACKLOG REG	BACKLOG NUC	ERND HRS	EXPND HRS	PROD EFF	PALT	EXPALT	TIME USAGE % EFFECT	% ACC	% LV	% OTH	TOTAL HRS	INCENT AWARD
						1-												
AJ	156	102	32		9	494		37.6	24.5	153	42.83	27.58	64	61		39	40.0	34.85
CK	70	125	60		18	378		59.3	34.8	170	39.66	18.36	46	73		28	48.0	65.17
CN	216	74	16		9	294		17.2	15.0	115	10.62	9.00	85	38	5	58	40.0	5.85
CW	102	69	36	7	16	214	47	40.5	32.5	125	34.38	23.48	68	81		19	40.0	21.28
EC	109	34	20		8	489		20.7	32.5	64	13.59	14.80	109	81		19	40.0	31.39-
EF																		
FK	68	99	39	3	15	454	47	52.0	34.0	153	60.67	42.95	71	85		15	40.0	47.88
MM	82	70	35			414	785	42.9	32.0	134	44.19	44.35	100	80	13	8	40.0	28.99
PK	97	108	57	2	12	315		58.0	36.0	161	27.60	26.54	96	75		25	48.0	58.52
PL	63	40	20		23	561		24.5	26.5	86	47.60	23.37	49	71		29	40.0	10.04-
RC	14	69	26			255	16	29.6	32.5	91	26.04	16.59	64	81		19	40.0	7.71-
TLS	959	798	341	12	112	3868	895	366.5	302.3	129	36.37	25.38	70	73	2	26	416.0	212.60

TL HRS REG : 355.8

TL HRS NUC : 53.2

Figure 1. Example of productivity efficiency report for small pruchase buyers.

4. JML BUY--Number of requisitions completed for the week.

5. NO. ORDR--Number of orders processed for the week. An order may contain more than one requisition.

6. NO. MOD--Number of modifications to previous purchase actions.

7. NO. T&C--Number of requisitions transferred to other buyers or cancelled.

8. BACKLOG--Number of regular (REG) or nuclear (NUC) requisitions remaining to complete purchase action at the end of each week.

9. ERND HOURS--Standard hours earned through completed purchase actions.

10. EXPND HOURS--Hours assigned to be spent on purchase actions.

11. PROD EFF--Earned hours divided by expended hours multiplied by 100. This is a performance efficiency measure. A value of 100 represents expected performance, the standard. A value greater (less) than 100 signifies above (below) standard performance.

12. PALT--Procurement average lead time. The number of days between the time when a requisition was received and when it was actually purchased.

13. EXPALT--Expected PALT. The number of days that the procurement was expected to take based on priority and critically of the material.

14. % EFFECT--EXPALT divided by PALT multiplied by 100--an index of how well PALT goals were being met.

15. % ACC--Percentage of time assigned to perform measured work.

16. % LV--Percentage of time on leave (annual, sick, etc.).

17. % OTH--Percentage of time spent doing nonmeasured work (special assignments, training, consultation with a union official, etc.).

18. TOTAL HRS--Number of payroll hours in a week.

19. INCENT AWARD--Amount of award earned.

At the end of each week, each branch supervisor received a copy of the PER that included productivity information for each member of his/her work unit. In addition, each employee received a report of his/her own performance. The PER received by the Support Services Branch was very similar in format but had column headings appropriate to their tasks.

PER Inputs

Individual productivity input is provided by two documents, the Transaction Code Sheet TC424X and the Personal Activity Log (PAL). Examples of these forms, along with instructions for completing them, are provided in Appendices D and E respectively. The TC424X is a modification of the standard TC424 that was used to input information concerning requisition status to the shipyard management information system. It was

designed to input required productivity data while adding a minimum amount of extra work to the existing requirement for status updating. The TC424X is prepared by each buyer or clerk whenever a buy/action is completed. The PAL is completed by each supervisor on a daily basis and contains a record of each employee's daily distribution of work and hours spent in all activities.

For a given week, employees spending a minimum of 30 percent of their time on measured work (work for which expended hours are credited) are eligible to earn hours toward an incentive award. On a weekly basis, a computer program calculates, for each employee, the hours earned for all tasks completed and the hours expended on measured work. The number of expended hours is then subtracted from the number of earned hours, and the difference multiplied by an incentive rate to determine the amount of the incentive award. It should be noted that, on a weekly basis, the award could be either positive (for hours saved) or negative (showing below standard productivity).

Incentive Rate

The sharing rate, the percent of hourly pay shared with the employee for performance above standard, was chosen to be approximately 30 percent of the average hourly salary rates. Therefore, employees could earn 30 percent of what they would normally earn for each hour they saved by their performance above standard. For example, an employee who worked for 40 hours and accumulated 44 earned hours would save 4 hours because of superior performance. For each saved hour, the employee in 1980 would earn an incentive rate of either $2.38/hour (.30 x 7.93) for buyers or $1.79 (.30 x 5.97) for clerks. Thus, a buyer with 4 saved hours would earn $9.52 toward an incentive award; and a clerk with 4 hours, $7.16. (This actually amounts to 3 percent of salary plus COLA for that week.) At the end of 2 weeks, the weekly totals (both positive and negative amounts) are accumulated. If the accumulated amount is $25.00 or more, the name of the employee and the amount of the award are forwarded to the incentive awards officer in the Industrial Relations Office (Code 150) for processing and payment. If the amount is less than $25.00, it is carried forward to the next biweekly report period to avoid the costs of processing an award for trivial amounts. If the amount is negative, it is dropped. To simplify keeping track of the amounts earned and paid to each employee, an employee incentive earnings report was computerized and updated biweekly (see Figure 2).

Summary of PCRS Design

The design of the PCRS can be summarized on the following dimensions:

1. Type of Performance Measure--Objective, quantitative (controlling for quality) based on accumulated standard times.

2. Information System--Computer-generated weekly efficiency report.

3. Aggregation Level--Individual performer.

4. Performance Period--Two-week intervals.

5. Feedback Period--Weekly.

6. Standard Level--Set at approximately 70th percentile of pre-PCRS rate of productivity.

HCLSOA SUPPLY DEPARTMENT BI-WEEKLY PRODUCTIVE EFFICIENCY INCENTIVE AWARD AWARD REGISTER ISSUE DATE 13 SEP 81 DATA DATE 12 SEP 81 PAGE 1

BRANCH CODE	IND ID	WK-ENDING 09-05-81	WK-ENDING 09-12-81	BI-WKLY NET BAL	PREV BAL 08-29-81	TOTAL AWARD	AMOUNT PAID	NEW BAL 09-12-81	AWARD TO DATE	PAID TO DATE
532	AI	.00	2.93	2.93	6.80	9.73	.00	9.73	519.73	510.00
532	CK	10.64-	6.65-	17.29-	30.27	30.27	.00	30.27	615.27	585.00
532	CW	45.22	36.71	81.93	68.83	150.76	.00	150.76	3335.76	3185.00
532	EC	8.51	14.36	22.87	.13	23.00	.00	23.00	283.00	260.00
532	EF	.00	.00	.00	.00	.00	.00	.00	.00	.00
532	FK	1.06-	6.38-	7.44-	41.54	41.54	.00	41.54	1141.54	1100.00
532	JJ	.00	.00	.00	1.39	1.39	.00	1.39	661.39	660.00
532	MH	53.73	23.94	77.67	1.35	79.02	.00	79.02	1414.02	1335.00
532	PK	13.30	46.55	59.85	74.82	134.67	.00	134.67	1059.67	925.00
532	PL	40.70-	8.51-	49.21-	25.52	25.52	.00	25.52	400.52	375.00
532	RC	21.81-	34.58	12.77	3.81	16.58	.00	16.58	566.58	550.00
532	ZZ	.00	.00	.00	.00	.00	.00	.00	.00	.00
	TOTAL	46.58	137.53	184.08	254.46	512.46	.00	512.46	9997.48	9485.00

Figure 2. Example of incentive award register for small purchase buyers.

7. Reward Type--Financial bonus above regular wages.

8. Sharing Rate--Thirty percent of hourly rate for average of middle step of appropriate grades.

9. Performance Reward Function--Positive linear function with .3 slope (16.7° angle) for performance above standard, and 0 slope for performance below standard.

10. Reward Ceiling--Determined by individual ability, anticipated to be 30 percent of base salary.

11. Reward Period--Two weeks following performance period for accumulated earnings of $25.00 or more.

RESULTS

The evaluation of the results are divided into three main sections corresponding to the three hypotheses previously mentioned (p. 6). The major objective of the first section is to evaluate the effect that the PCRS implementation had on production effectiveness and efficiency. The second section compares the trial period under the PCRS to prior production conditions at the test-site in terms of cost. The last section reviews the cost-effectiveness of the PCRS and evaluates test-site savings projections.

Impact on Productivity and Production Effectiveness

Discussion

The nonmonetary dimensions of production effectiveness on which the impact of PCRS implementation was evaluated were: (1) the level of production, as measured by total requisitions, (2) the number of adjusted labor-hours expended in production, (3) the efficiency of production, as measured by requisitions per labor-hour, and (4) the process quality, as measured by (a) the number of higher cost overtime labor-hours used to meet required levels of output, (b) the amount of backlog or work in process, and (c) the average number of days it took to procure each requisition (the PALT). Table 3, which provides the results of the production effectiveness evaluation for the small purchase buyers and supply clerks combined, the buyers only, and the clerks only, shows that the test site's overall productivity and effectiveness were increased by PCRS implementation when evaluated in terms of nonmonetary units. Each of the respective values of data corresponding to the dimensions of level and prodctivity of the production process was better during the trial period than during the base period.

The major finding in the combined results is that overall production efficiency in terms of requisitions per labor-hour increased significantly--from 1.73 to 2.18 (26%). This was acccomplished by raising the level of requisition production by 13.5 percent and reducing the total adjusted labor-hours used by 9.6 percent. Overall process effectiveness also increased significantly. Overtime labor-hours were reduced by 94 percent, workload backlog for the buyers was cut 51.7 percent, and procurement average lead time in days dropped by 42.6 percent. In addition, the direction of change on all facets of level of production, productivity, and process effectiveness was highly desirable between the base and trial periods.

Table 3

Comparative Productivity and Effectiveness of Base and Trial Periods

Item[a]	Base[b] Period (Weekly Means)	Trial[c] Period (Weekly Means)	Direction and Amount of Change (%)	Direction Desirable?	Test for[d] Significance (p)
Buyers and Clerks Combined					
Level of Production					
Requisitions	1,280.18	1,453.18	+13.5	Yes	<.01
Production inputs used (adjusted labor-hours)	739.12	668.12	-9.6	Yes	<.01
Productivity Efficiency					
Requisitions per labor-hour	1.73	2.18	-26.0	Yes	<.01
Process Effectiveness					
Excess-cost penalties (overtime labor-hours)	11.76	.71	-94.0	Yes	<.01
Workload in process (buyers only)	4,786.00	2,310.00	-51.7	Yes	<.01
Procurement average lead time (mean days)	38.19	21.94	-42.6	Yes	<.01
Buyers Only					
Level of Production					
Requisitions	626.29	710.94	+13.5	Yes	<.01
Production inputs used (adjusted labor-hours)	318.06	307.29	-3.5	Yes	<.01
Productivity					
Requisitions per labor-hour	1.97	2.31	+17.5	Yes	<.01
Process Effectiveness					
Excess-cost penalties (overtime labor-hours)	7.53	0.00	-100.0	Yes	<.01
Workload in process	4,786.00	2,310.00	-51.7	Yes	<.01
Procurement average lead time (mean days)	38.19	21.94	-42.6	Yes	<.01
Clerks Only					
Level of Production					
Requisitions	653.88	742.24	+13.5	Yes	<.01
Production inputs used (labor-hours)	421.06	360.82	-14.3	Yes	<.01
Productivity					
Requisitions per labor-hour	1.55	2.06	+32.9	Yes	<.01
Process Effectiveness					
Excess-cost penalties (overtime labor-hours)	4.24	.71	-83.3	Yes	<.01

[a]The dimensions of productivity and effectiveness listed were selected on the basis of relevance to test-site management's goals of increasing the level, efficiency, and effectiveness of requisition work-flow.

[b]The base period extended from 4 June to 29 September 1979. It included 2 holidays and 83 work days.

[c]The trail period extended from 2 June to 27 September 1980. It included 2 holidays and 83 work days.

[d]Tests for statistical significance are shown because any statistically significant differences found would further validate the stability of productivity and production effectiveness improvement during the trial period. Furthermore, the PCRS's capability to continue to generate significantly improved productivity and effectiveness in future periods on a sustained basis is of interest.

Conclusions

On every measure of productivity and production effectiveness chosen, the trial period was superior to the base period. This was true for both small purchase buyers and supply clerks, whether results are analyzed separately or combined. Therefore, the answer to the first question addressed by this report is positive. The PCRS implemented in the Purchase Division significantly increased productivity.

PCRS Production-Cost Savings

The second question is whether PCRS implementation resulted in cost savings. The purpose of this section is to measure and evaluate developmental costs, production-cost savings, and net savings of the PCRS. It is important that the costs associated with implementing the PCRS be evaluated before any possible benefits are analyzed.

Developmental Costs

Table 4, which provides the PCRS nonrecurring developmental costs, represents a concerted effort to include all such costs associated with implementing the PCRS. As shown, the major cost was the $90,000 charged by NAVPERSRANDCEN to the shipyard. These costs will be prorated over a 2-year period, which approximates the time frame used from initial conception of the PCRS until evaluation of the results was completed. All other developmental costs will be amortized straight-line over the 1-year period that separated the base period from the trial period.

Table 4

PCRS Nonrecurring Development Costs

Item		Amount ($)
Recorded Costs		
NAVPERSRANDCEN costs--charged to shipyard		90,000.00
Shipyard internal costs		21,041.16
Supply Department	7,361.40	
Management Engineering and Information Office	11,893.20	
Industrial Relations Office	1,786.56	
Possible Unrecorded Costs--(Estimated 5 percent of total shipyard internal costs)		1,052.06
Total		112,093.22

The overall cost savings of the PCRS relative to the costs of former production conditions among the buyers and clerks at the test-site can be meaningfully compared by concentrating separately on (1) the savings created by production-cost reduction, and (2) the net savings remaining after all setup costs were absorbed.

Production-Cost Savings

The production-cost savings were determined using comparative data on two basic dimensions: production costs and production output. The test-site comptroller derived and periodically updated the cost rate (CR), which represents the overall hourly production cost, per buyer and clerk. The CR included the following aspects of the purchase division operation:

1. Buyers' and clerks' basic salaries.
2. The government's share of the workers' pension and other benefits.
3. Supervisors' salaries.
4. Cost of living allowance.
5. General overhead.

Table 5, which compares production costs for the 1979 base period and the 1980 trial period for buyers and clerks combined, shows that combined production costs declined from $178,436.97 in the 17-week base period to $166,491.92 in the 17-week trial period after PCRS implementation.

Table 5

Comparative Production Costs of Base and Trial Periods--Buyers and Clerks Combined

Item	Base Period Costs	Trail Period Costs
Cost rate x labor-hours[a]	$ 177,787.85	$ 161,701.84
Overtime rate x labor-hours[b]	649.12	32.88
PCRS bonus payments	---	2,119.99
PCRS administrative costs[c]	---	2,637.21
Total	$ 178,436.97	$ 166,491.92

[a]The current combined cost rate (CR) is $14.24 per hour. The base period used a total of 12,565 labor-hours.

[b]The overtime rate (OT) is 1.5 times the basic hourly salary. Overtime labor-hours for the base and trial period were 200 and 12 respectively.

[c]Estimated by test-site management.

The production-cost savings can be obtained by multiplying the interperiod difference of cost-per-requisition (unit costs) by the output of the trial period, as illustrated in the following equation:

$$\left[\frac{X_b}{Y_b} - \frac{X_t}{Y_t}\right] Y_t = S_t \qquad (3)$$

where

X_b = Production costs in base period,

Y_b = Production output in base period,

X_t = Production costs in trial period,

Y_t = Production output in trial period, and

S_t = Production cost-savings in trial period.

Based on equation 3, the production-cost savings were computed as follows:

1. Combined buyers and clerks:

$$\left[\frac{\$178,436.97}{21,763} - \frac{\$166,491.91}{24,704}\right] \times 24,704 = \$36,058.61.$$

2. Buyers only:

$$\left[\frac{\$86,044.65}{10,647} - \frac{\$85,135.40}{12,086}\right] \times 12,086 = \$12,538.65.$$

3. Clerks only:

$$\left[\frac{\$92,392.32}{11,116} - \frac{\$81,356.51}{12,618}\right] \times 12,618 = \$23,519.91.$$

As shown above, the production output figures, in terms of cumulative requisitions with buyers and clerks combined, for the base and trial periods increased from 21,763 to 24,704 while production costs decreased from $178,436.97 to $166,491.92. As a result, $36,058.56 in production-cost savings were generated during the 17 weeks of PCRS evaluation of 22 civil service small purchase buyers and supply clerks at the shipyard. About two-thirds of the cost savings during the trial period were made by the clerks.

Net Savings

The net savings generated during the trial period were the production-cost savings remaining after subtracting the nonrecurring development or set-up costs (Table 4). Thus, the production-cost savings of $36,058.61, when reduced by the prorated share of first-year setup costs--$21,934.32[3]--left a net cost savings during the trial period of $14,124.29.

The net savings of the trail period, as obtained above, should be carefully interpreted. The key issue here is whether or not it is appropriate to absorb, during the trial period itself, all of the nonrecurring setup costs incurred during PCRS implementation. An alternative method (the one chosen here) is to recover the setup costs by prorating them over a specified number of accounting periods that approximates the expected life of the project. Although this procedure would significantly increase the net savings for the trial period if they were spread out straight-line for, say, a 5-10 year period, it would reduce the production-cost savings during the periods over which the setup costs are prorated. In this study, each setup equivalent cost was spread out over a period of time equivalent to the period when these costs were actually expended. Thus, all internal shipyard developmental costs were amortized straight-line over the first year of the PCRS after implementation. The NAVPERSRANDCEN costs ($90,000), as stated previously, were prorated straight-line over a 2-year period, which approximated the time frame used from initial conception of the PCRS until initial evaluation of the program was completed.

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[3]The prorated share of the first-year setup costs was calculated from the data in Table 4 as follows: 17/52 (21,041.16) + 17/52 (1,052.06) + 17/104 (90,000) = 21,934.32. See explanation in text.

The short prorated periods method used demonstrates emphatically that such costs were less than the savings generated solely from reductions in production costs during the same period. It is very important to note that all nonrecurring setup costs (including those for NAVPERSRANDCEN) would be fully recoverable after about 1 full year of PCRS operation (see Appendix F). Few investments have such short "payback" periods. Furthermore, the likely recovery periods for other Navy sites implementing the PCRS would be even shorter when possible economies of scale are included. In other words, the setup costs of similar Navy sites employing buyers and clerks and implementing the PCRS can reasonably be expected to decrease significantly. For example, costs could be reduced by appropriately adapting the software developed at the test-site to meet the relevant specifications of other Navy locations. These adaptions would effect major reductions in setup costs when compared with the alternative of each site developing its own software from scratch.

Interrelationships among the PCRS setup costs, net savings, and production-cost savings have now been analyzed in terms of their effect on the monetary results of the 17-week trial period. Based purely on the reduction of production costs, savings exceeded $14,000 (see Table 6) for the PCRS trail period. Given that this period involved only 22 subjects for 17 weeks, such savings are noteworthy. Thus, the hypothesis that the PCRS was able to produce significant net cost savings to the government during the trial period while, at the same time, production effectiveness increased was supported. Furthermore, these results from preliminary cost-effectiveness analysis are likely to have understated greatly the full potential of the PCRS for long-range cost reductions of purchase division activities. Some of the main reasons for the probable understatement would include the following:

1. The increase in productivity during the 17-week trial period led to the 51.7 percent reduction of buyer workload backlog accumulated prior to PCRS implementation (Table 3). As a direct result, there frequently was insufficient work to keep all buyers busy, thus restricting the potential productivity.

2. This analysis assumed stable labor costs based in 1980 dollars. This presents a very conservative approach since labor costs in 1981 and 1982 have already escalated 11.8 and 5.2 percent respectively. Labor costs will likely continue to increase significantly in the future.

3. Capital depreciation charges are included in the shipyard overhead rate for 1981 and beyond but were not included in the 1980 rate. Thus, the dollar savings estimates from increased production efficiency and effectiveness from adopting the PCRS in future years would accelerate.

Test-Site Savings Projections

While the net savings associated with implementing the PCRS were significant in and of themselves, of far greater interest to test-site management and other evaluators is the cumulative value of the PCRS savings when projected through specified outyears. Projections based on a lump-sum savings in the trial period in excess of $14,000 and projected biweekly savings representing 1, 2, 3, and 5 outyears are shown in Table 6.

The projection lists cumulative values by combining the actual net savings generated during and after the 17-week trial period. The production-cost savings were compounded biweekly because the shipyard used a biweekly period of performance to determine the

Table 6

Purchase Division Savings: Actual and Projected

Outyear (end-of)	Lump-Sum Savings Compounding[a] (1) Lump-Sum Savings ($)	(2) Compounding Factor[c]	(3) Compounded Value ($) (1)x(2)	Periodic Savings Compounding[b] (4) Projected Biweekly Savings ($)	(5) Compounding Factor[d]	(6) Compounded Value ($) (4)x(5)	(7) Compounded Lump-Sum Savings Biweekly ($)	(8) Total Prior Periodic Savings Compounded ($) (6)+(7)	Total Savings Value (9) Lump-Sum & Periodic Savings ($) (3)+(8)
1	14,123.95	1.11	15,677.58	1,499.78	27.356	41,027.98	0.00	41,027.98	56,705.56
2	14,123.95	1.23	17,372.45	2,349.47	27.356	64,272.10	45,541.74	109,813.84	127,186.29
3	14,123.95	1.37	19,349.81	4,080.24	27.356	111,619.04	121,893.42	233,512.46	252,862.27
5	14,123.95	1.69	23,869.47	4,080.24	57.740	235,593.06	287,220.33	522,813.39	546,682.86

Note. Projections for the periodic savings are based on coinciding compounding and series-payment intervals, as described in Fabrycky and Thuesen (1974). Interest rate used is 10 percent as prescribed in DODINST 7041.3 (18 October 1972). All projected savings are in net future values (NFV) that reflects effective values at the end of the specified outyear.

[a]Actual cost savings after absorbing a prorated share of all setup costs recorded during the 17-week PCRS trial period. Shipyard development costs are amortized straight-line over a 1-year period; NAVPERSRANDCEN development costs are prorated straight-line over a 2-year period.

[b]Projected cost savings after PCRS trail period ended, exclusive of setup costs that were absorbed previously.

[c]Assume that the actual trial-period net savings were "deposited" 2 weeks after that period ended, on a lump-sum basis.

[d]Assume that the first payment of projected production-cost savings had accrued exactly 2 weeks after trial period ended, and would recur biweekly. Because the projected biweekly savings changes in years 1, 2, and 3, the compound factor for 1 year is used. Since the savings rate for years 4 and 5 remains the same, the compound factor for 2 years is used.

eligibility of individual buyers and clerks to receive cash bonuses. Since such awards represented a portion of the production-cost savings that had already accrued during the biweekly accounting period, projections based on coinciding compounding and periodic-payment intervals are warranted (Fabrycky & Thuesen, 1974). In the present case, this simply means that the production-cost savings previously accrued were compounded on the same date that the next biweekly increment of savings was acccrued.

The lump-sum savings are also compounded biweekly to coincide with the compounding cycle of the production-cost savings. This facilitates interpretion of the cumulative projected value derived from combining the actual trial period net savings and the projected production-cost savings. It should be noted, however, that biweekly compounding of the lump-sum savings likely represents a conservative bias in the overall projections because many financial institutions would compound such lump-sum savings on a "daily" or a "continuous" basis, which translates into a higher yield.

Table 6 demonstrates that outyear lump-sum and periodic savings in net future values (NFV) to the government for 1, 2, 3, and 5-year periods would be in excess of $56K, $127K, $252K, and $546K respectively. These amounts are derived from using a mandated DoD interest rate of 10 percent as applied against only the small group of 10 small purchase buyers and 12 supply clerks. If the PCRS was spread to the Navy supply community as a whole, with the same degree of success, the projected costs savings over a 5-year period would amount to many millions of dollars.

These results show the benefits of the PCRS to the shipyard in terms of NFV. There are, however, alternative methods that can be used to evaluate the financial value of a program such as this. These alternatives are discussed in Appendix F.

Conclusions

The PCRS in the Supply Department at the shipyard meets and exceeds the standards imposed by sophisticated F&EA. The NFV payback method, NPV, and the B/C ratio (discussed in Appendix F) all demonstrate the desirability of adopting and maintaining the program in the Supply Department. Millions of dollars in outyear savings could accrue to the government by spreading the PCRS to other buyers and clerks in the Navy supply community.

In conclusion, the hypothesis that the implementation of the PCRS is cost-effective and will generate significant net cost savings to the government has been confirmed. This study was both a replication and an extension of the Long Beach Naval Shipyard (LBNSY) data transcribers' successful experience with a PCRS. The results in the present study demonstrate that a PCRS incentive plan can also significantly enhance efficiency and effectiveness in more complex task environments such as represented by the small purchase buyers and supply clerks.

Program Satisfaction

The final question addressed by this research was whether or not the employees, supervisors, and management of the Supply Department were satisfied with the program. To answer this question, all available participants, supervisors, and management personnel, as well as a random sample of all department employees not participating in the program, were administered a short (38 items) evaluation questionnaire. The anonymity of all respodents was protected so that honest and forthright responses might be obtained.

Thirty-seven of the items were designed to determine respondents' perceptions of 10 conditions of the the program. The final item asked them whether they wanted the program to continue. The 10 conditions chosen for evaluation were:

1. The work requirements to earn an award were clear.
2. Negative side effects were perceived.
3. The PERs were valuable.
4. The standards were fair.
5. The distribution of work was fair.
6. The administration of the program was simple.
7. Individuals were unfairly manipulating the system.
8. The program would work better by using larger awards.
9. The program has positive value.
10. Enough of the job tasks were included under the program.

For each of these conditions, multiple items were presented. The items included both positively and negatively worded statements to help avoid biasing the results. The respondents were to indicate their agreement or disagreement that the condition existed, using a 5-point scale, where 5 = strongly agree and 1 = strongly disagree. The questionnaires were scored by averaging the item values for each of the conditions. Negatively worded items were reverse scored to make them consistent with the other items. The average item score for each condition, therefore, indicated how positively or negatively that condition was viewed.

Table 7, which presents questionnaire results, shows that both participants and supervisors/managers perceived the program as positive on all conditions but one. Most believed that the program should include more tasks associated with the employees jobs. Although participants and supervisors/managers were positive toward the program's clarity, value, and fairness, the nonparticipants held different perceptions. They are much less certain about the value and fairness of the program. Since these employees had only learned of the program through hearsay and not actual experience, this should not be surprising. There is also some evidence to suggest that the nonparticipants were more negative because they were somewhat resentful of not having the opportunity to be included in the program. Reports from the president of the shipyard union, as well as the union shop steward, indicated that many employees had inquired as to when they might be included in the program. They also felt it unfair for the Purchase Division to have the program if other divisions would not be eventually included or at least be given justification for their exclusion.

Throughout the program's development and implementation, the union representing these employees maintained a "wait and see" attitude toward the program; union leaders were willing to allow experimentation while maintaining their right to negotiate with management over program issues they felt involved "conditions of work." As long as the employees participating in the program desired that it continue, they were willing to defer formal negotiations. However, if specific problems arose, they indicated they would withdraw support and request formal negotiations. As shown in Table 7, the support for the program has been strong enough that such action was not necessary. Eleven of 15 participants (73%) wanted the PCRS program to continue, even though several of them had not yet earned or received any financial awards. Supervisors and managers were even more supportive (83%) while nonparticipants, as would be expected, were less supportive (46%). These figures suggest that persons with direct experience with a PCRS are likely to support it even when they may have been cautious or dubious initially.

Table 7

Responses to Evaluation Questionnaire

Item	Total (N=34)	Participants (N=15)	Non-participants (N=13)	Supervisors/ Managers (N=6)
Evaluation of Program Attributes[a]				
1. Requirements are clear	4.27	4.37	4.08	4.17
2. No negative effects	4.04	4.38	3.26	4.61
3. Reports are valuable	3.96	4.01	3.43	4.28
4. Standards are fair	3.88	3.97	3.30	4.25
5. Distribution of work is fair	3.75	3.81	3.19	4.30
6. Administration is simple	3.72	3.78	3.49	3.90
7. Manipulation not done	3.53	3.53	3.31	3.88
8. Better with more money	3.48	4.08	2.74	3.33
9. Program has positive value	3.45	3.71	3.00	3.54
10. Enough tasks included	2.38	2.40	2.50	2.17
Overall total	3.59	3.80	3.21	3.84
Desire to Continue the Program[b]				
1. Continue the program	22 (65)	11 (73)	6 (46)	5 (83)
2. Undecided	8 (23)	2 (13)	5 (38)	1 (17)
3. Discontinue the program	4 (12)	2 (13)	2 (15)	0 (0)
Total	34	15	13	6

[a]Results based on responses to a 5-point scale, where 5 = strongly agree and 1 = strongly disagree.

[b]Results based on response frequency; the numbers in parentheses are percentages.

In summary, the answer to our third question is also positive. The employees, supervisors, and managers involved in the program are generally satisfied with the program and desire it to continue.

RECOMMENDATIONS

The results indicate that a PCRS could be successfully applied to more complex jobs and more highly trained and paid employees than those included in studies of key entry operators. When these results are compared with the key entry findings, it appears that properly designed and implemented PCRS systems that are given top management support can increase employee motivation and productivity in a wide range of jobs.

Further research on the limits of these results and related issues needs to be conducted. Although this particular form of PCRS has been shown to increase motivation and productivity over the period studied, very little is known about the optimal values for the various dimensions in its design. Furthermore, there is very little in the scientific literature that can answer important questions about PCRS design. A few of these questions are:

1. What would be the effect of using rewards other than money (e.g., time off and prizes)?
2. What is the most effective sharing rate?
3. How long should the period of performance be before calculating awards?
4. What is the optimal performance-reward function?
5. What is the optimal level to set the standards?
6. How often should feedback be given?
7. How do group awards compare with individual awards?
8. How often should the actual award be made?

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APPENDIX A

PRODUCTIVITY MEASUREMENT: ISSUES, CONCEPTS, AND METHODS

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Measuring Output

Measuring output can seem to be relatively simple when output is a tangible item (requisitions processed, keystrokes entered, number of pages of typing, engines overhauled, etc.). Sometimes it is. By assuming that all units are equivalent, the output measure can be just a count of the number produced. For example, a convenient measure of output for a typist may be the number of pages typed. If each page of typing is generally equivalent to all others, there should be no problem. What often is at issue is whether or not a given number of pages typed by one person or group is equivalent to the same number of pages typed by another person or group. If so, the raw number of units produced is the easiest output measure to obtain. However, if equivalency cannot be assumed (as is often the case), the measurement needs to be more complicated. Sometimes the units can be made commensurable by changing the quantification to smaller units. For example, going from the number of pages typed to the number of lines typed can help avoid the nonequivalency of typing pages of different lengths. By further reducing the measurement unit to the number of characters typed, additional ambiguities can be further reduced.

A second way to make the units commensurable is to separate different categories of the output and then count the number in each category. Once again using typing as an example, the number of pages of draft and final copy typing may be counted separately. This assumes, of course, that each unit within a category is roughly equivalent. While this may be a useful strategy, it would be difficult to get a general picture of productivity increases or decreases if there are a large number of categories (four or more). If the same group or individual performs work in all categories, it becomes difficult to know how an increase in one category can be balanced against a decrease in another.

A third method frequently used to make comparable measures is by aggregating more observations, usually by either increasing the number of individuals or the length of time included in the measurement period. Justification for this method comes from statistical sampling theory where increasing sample size has been shown to decrease the error of the mean. The larger the sample, the more likely that typical units will represent a small percent of those included and will cancel each other out. This then produces a representative count. For this method to be of value, however, the distribution of work among the larger group or longer time must be comparable. The chief advantage of this method is that it can produce accurate results inexpensively. Its major disadvantage is that the larger aggregations make it difficult, if not impossible, to give either rapid or individual feedback to employees and managers.

The final way of dealing with these complexities at the organization level is to quantify the output into some standard units that are inherently commensurable. This is usually done by converting the number of raw output units into some standardized units. Frequently, this means converting to standard hours. To illustrate, if it generally takes 10 minutes (.167 hours) to type a page of rough draft and 12 minutes (.20 hours) to type a page for final copy, a typist's or group's output can be determined by converting each page to its equivalent in standard hours and then summing all hours. For example, assume an individual typed 24 pages of rough draft and 20 pages of final copy. Output could be measured as the total number of pages, the number of pages of each category, or as the standard hours of work accomplished ((24 x 10) + (20 x 12) = 480/60 = 8 hours)). This method of measuring output has many advantages. Two of the most important ones are that (1) it is easier to combine outputs with dissimilar raw units into a total output measure, and (2) outputs are more comparable across time and groups. As should be apparent, the more accurate the conversion algorithm, the greater the value of this method.

Measuring Input

The resources used in the production of output are usually called inputs. The four resources most commonly considered as important inputs are: (1) labor, (2) capital, (3) materials, and (4) energy (Siegel, 1980). Of these, labor is by far the most widely used (Greenberg, 1973) although, as work becomes more and more automated, capital and energy become more important. Labor is usually measured as hours worked and, sometimes, as hours paid for. It is often useful to measure labor hours more specifically by measuring the hours actually worked on the units of output. This then allows a more precise accounting of the productivity of labor for the output in question. The number of dollars spent on labor is also used at times as a labor input, but care must be taken to express dollars in constant terms (corrected for inflation) to make any meaningful comparisons across time or location.

Labor productivity is computed by dividing the units of output (number of units or standard hours) by the labor hours used in their production. If, for example, a clerk typed 44 pages in 8 hours, his/her labor productivity would be calculated as follows:

$$\text{Productivity} = \frac{\text{Measured Output}}{\text{Measured Input}} = \frac{44 \text{ pages}}{8 \text{ hours}} = 5.5 \text{ pages per hour.}$$

or

$$\text{Productivity} = \frac{\text{Measured Output}}{\text{Measured Input}} = \frac{8 \text{ standard hours}}{8 \text{ hours}} = 1.0.$$

Quantity vs. Quality

Any discussion of labor productivity and the need to improve it is likely to raise the issue of quantity vs. quality. Often the concern makes it seem as if quantity and quality are on opposite ends of a continuum. Of course, this is nonsense. There is no reason to believe that, just because a product takes a long time to complete, it will be of high quality. It is more useful to think of quantity and quality as two separate dimensions of productivity.

Quantity is the number of units completed in some time period and quality is the degree to which each unit of output possesses desirable characteristics. The number of pages typed per hour, the number of steam valves overhauled per hour, and the number of requisitions processed per hour are all quantitative measures of productivity. The quality of these outputs depends on their accuracy and adherence to specification. Fewer errors or closer conformity to specifications are indications of better quality.

Logically, these two dimensons can be independent of one another. Depending upon the nature of the task, organizations typically focus their attention on one of the dimensions, measure it, and hold the other constant. For example, before a typed letter would be counted as an output, it normally would have to meet some quality standards (form, accuracy, etc.). Requiring each letter to pass this quality control before it is counted as an output is an effective way to ensure that improvements in quantity do not hurt quality. If all workers understand these quality standards and they build in or assure the quality initially, the amount of wasted lost time is significantly reduced. It is much better to do it right the first time.

Figure A-1 shows how quantity and quality should be conceptualized. The top half of the figure shows how quantity can be measured by holding quality constant; that is, minimum standards must be met for an output to be counted. Sometimes maximum quality standards are also specified to avoid a "gold-plating" problem. This philosophy is expressed in the statement, "'Better' is the enemy of 'good enough'." Recognizing that "better" is often more expensive than "good enough," it becomes obvious that we can sometimes do more than is prudent. Although this method of controlling quality and measuring quantity is the most frequent method of dealing with the quantity-quality issue, it is not appropriate in many instances. Certain jobs or tasks have as their goal the quality of productivity rather than quantity. These jobs or tasks are sometimes those where the quantity cannot be controlled by the workers; therefore, the quality of each output is the basis for evaluation. For example, some quantitative aspects of the work of firemen (e.g., how many fires they are summoned to extinguish) are not usually under their control but the quality of their performance at each fire (e.g., the quality of their producing an extinguished fire) is critical. This alternative, as shown in the bottom half of Figure A-1, measures productivity while holding quantity constant and measuring quality. Using the example of firefighters, the following questions might be asked:

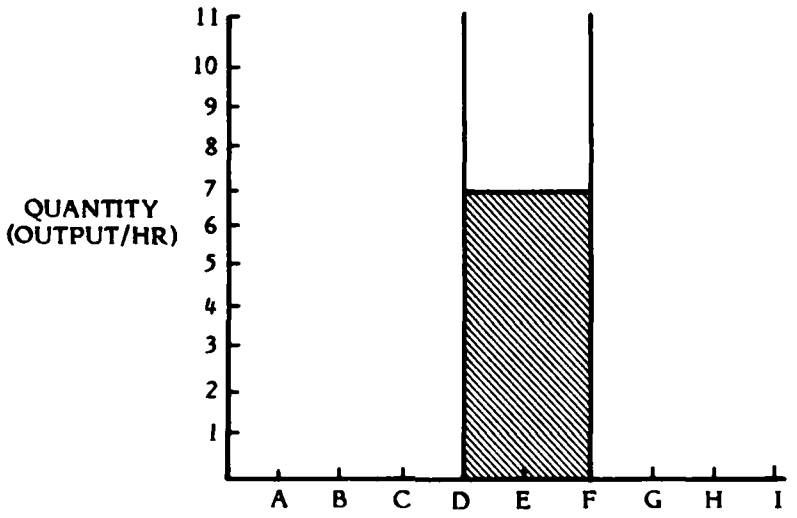
1. When called upon twice a week, how satisfactorily does the fire company extinguish fires?

2. How accurately did they meet fire fighting standards?

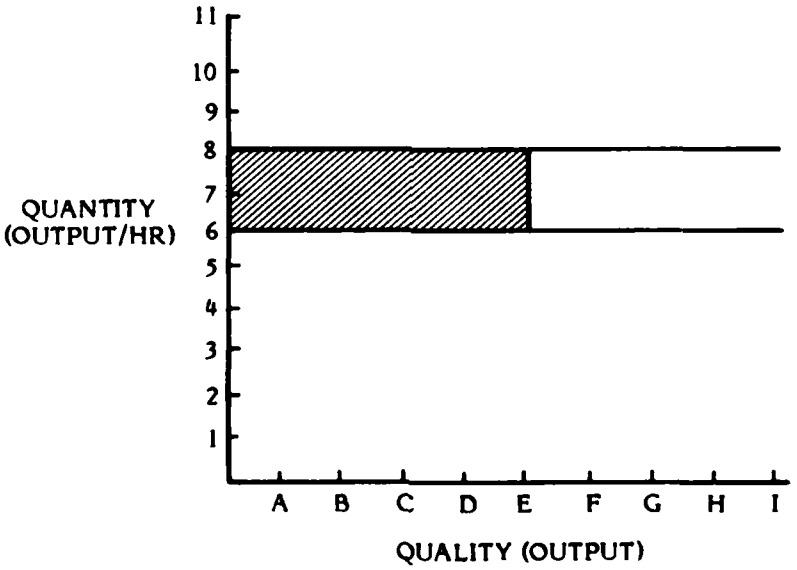
3. Were their methods creative or innovative?

4. How pleased were those for whom the services were provided?

Many tasks in organizations are of this type. Any position that demands that the incumbent react to an unpredictable situation (e.g., receptionists, security guards, radarmen, etc.) falls into this category.



a. Measure quantity, holding quality constant.



b. Measure quality, holding quantity constant.

Figure A-1. Measures of productivity.

APPENDIX B

DETERMINANTS OF PRODUCTIVITY

DETERMINANTS OF PRODUCTIVITY

From a theoretical perspective, a number of things should be important in determining productivity. Two equations that seem particularly useful in understanding what will be the major infuences over productivity are those expressed by the following:

$$\text{Behavior} = f(\text{Person, Environment}) \qquad \text{(B-1)}$$

$$\text{Performance} = f(\text{Ability} \times \text{Motivation}) \qquad \text{(B-2)}$$

If it is assumed that productivity is performance behavior, it can be substituted for behavior in equation B-1 and for performance in equation B-2. These equations then allow us to build a model of productivity determinants that can be very useful. Such a model, for example, recognizes that aspects of both the person and the environment have an effect upon productivity through their influence upon ability and motivation.

A Productivity Model

Figure B-1 presents the productivity determinants model and some examples of the variables that are representative of the four categories shown. In the person-ability quadrant of the model, those personnel characteristics that limit the capacity of individual workers to be productive are listed. Their intelligence, knowledge, physical capacities, and skills will have an impact upon their ability to be productive. This list is by no means meant to be exhaustive but merely to illustrate the kinds of variables that fall in this quadrant. The environmental attributes that are likely to have a major influence upon the productive ability of the workers are shown in the environment-ability quadrant. These include the way an organization or work group is designed and managed, the tools and equipment available, the nature of the task, the methods used to accomplish it, and the physical conditions (lighting, heat, noise, etc.) of the work.

	ABILITY FACTORS	MOTIVATIONAL FACTORS
PERSONAL ATTRIBUTES	Intelligence/Knowledge Physical Capacities Skill	Persistent Desire to Excel and Other Needs Consistent Beliefs About Ability to Perform Consistent Beliefs Concerning Performance Outcomes
ENVIRONMENTAL ATTRIBUTES	Management & Coordination of Activities Tools & Equipment Task Content & Methods Work Conditions	Group Norms and Sanctions Organizational Reward System Job Design

Figure B-1. Productivity determinants model.

The person-motivation quadrant represents the attributes that workers carry from situation to situation that motivate them to be productive. These include their desire to excel (need for achievement), general or nonsituationally derived beliefs in their own competence (or lack of it), and general or nonsituationally derived beliefs in the consequences of performance. Finally, the environment-motivation quadrant lists those variables that are part of the work situation and that have a major influence upon motivation. They include the norms and sanctions of the work group toward high and low producers, the financial and nonfinancial rewards administered by the organization, and the design of the task or job itself.

This model provides a useful system for generating and categorizing the variables that are important determinants of productivity. In addition, it provides a useful scheme of categorizing the various techniques that have been developed for improving productivity. While these techniques are many and varied, most of them can be identified as attempting to change one or more of the variables in the model's quadrants. Although matching the many techniques available for improving productivity with the model is beyond the scope of this paper, Figure B-2 lists a few examples and shows their relationship to the productivity determinants model.

	TECHNIQUES TO ALTER MOTIVATION	TECHNIQUES TO ALTER ABILITY
TECHNIQUES TO INFLUENCE PERSONNEL	Aptitude Testing and Selection Skill Training	Attitude/Personality Testing and Selection Motivation Training
TECHNIQUES TO INFLUENCE ENVIRONMENT	Organization Design Technology Improvements Work Simplification Information Systems Quality Circles	Incentive Plans MBO/Goal Setting Performance Appraisal Job Enrichment

Figure B-2. Examples of techniques to increase productivity.

The techniques shown in Figure B-2 are discussed below.

1. Person-ability quadrant. These techniques usually emphasize classical personnel psychology. The selection of individuals based on aptitude and skill testing has positively contributed to the improvement of productivity in organizations. By bringing in those individuals most likely to succeed, productivity is enhanced. Training programs to improve employee skill in accomplishing their jobs has also had a positive impact upon productivity by improving individual ability.

2. Environment-ability quadrant. These techniques have most often been developed by persons in industrial engineering, management science, and the behavioral sciences. Many valuable contributions have been made in this area. The easily recognized techniques in this quadrant are those that use new technology to improve the tools and equipment used in productive activity. Computers, automated equipment, robots, etc. are just a few of the obvious examples. Other techniques are also well represented here. Perhaps overworked but often effective is the redesign of the organization, its division of labor and coordinating mechanisms. Work simplification techniques to eliminate unnecessary steps and motion are also effective in increasing worker ability to be productive. Techniques to improve the information available for planning and decision making are also designed to increase ability to be productive. A technique widely used in Japan and now receiving increasing use in the U.S. is known as Quality Circles or Quality Control Circles. These worker groups are formed to solve production problems that prevent workers from being productive.

3. Person-motivation quadrant. These techniques are logically similar to those used in the person-ability quadrant but with a different focus. Some are designed to find highly motivated individuals (or individuals likely to be more motivated in certain jobs than others) so they can be properly selected or matched to jobs. Others are designed to train or develop motivation. Informal methods (e.g., pep talks), as well as formal methods (e.g., motivation seminars and need achievement training) fall into this category. These techniques are probably used most frequently with sales personnel. Up to this point, the documented benefits of these programs have not been as strong as the techniques of the other quadrants.

4. Environment-motivation quadrant. These techniques, which are designed to change the work environment to enhance motivation, recognize the importance of the environment in influencing individual motivation (e.g., changes in the environment can produce substantial changes in motivation). Incentive plans, MBO/goal setting, and performance appraisal are all aimed at altering the consequences of productivity so that improvement "counts" toward things of value to the individual. Job enrichment seeks to influence productivity by making high productivity more interesting, fun, and challenging, thereby enhancing individual motivation to do well. Support for the effectiveness of some of these methods is substantial. Improvements in productivity often exceed 40 percent (Dockstader, Nebeker, Nocella, & Shumate, 1980; Locke, 1980).

Ability vs. Motivation

Frequently, there is debate over whether abilty or motivation is more important in making productivity improvement. More specifically, it is often suggested that capital investments in ability-enhancing and labor-saving tools and equipment (environment-ability quadrant) are the most important aids to improved productivity. Further, it is even argued that low productivity due to low motivation may be compensated for by technology improvements. The recognition that ability and motivation combine multiplicatively to determine productivity help put these arguments in proper perspective.

Figure B-3, which illustrates how changes in motivation at three different levels of ability impact on productivity, shows that they have an increasing effect upon productivity at higher ability levels. This has several important implications. Two are mentioned here. The first is that, if ability differences are primarily due to personal attributes, paying attention to the motivation of high-ability individuals will have a greater return for an equal motivation improvement. For example, suppose employees A and C both improved from 60 to 80 percent motivation. The productivity improvement for employee A would be 4.0 units/hour ((.80 x 20) - (.60 x 20)), while that for employee C would only be 2 units/hour ((.80 x 10) - (.60 x 10)). This is a 100 percent difference in the amount of improvement.

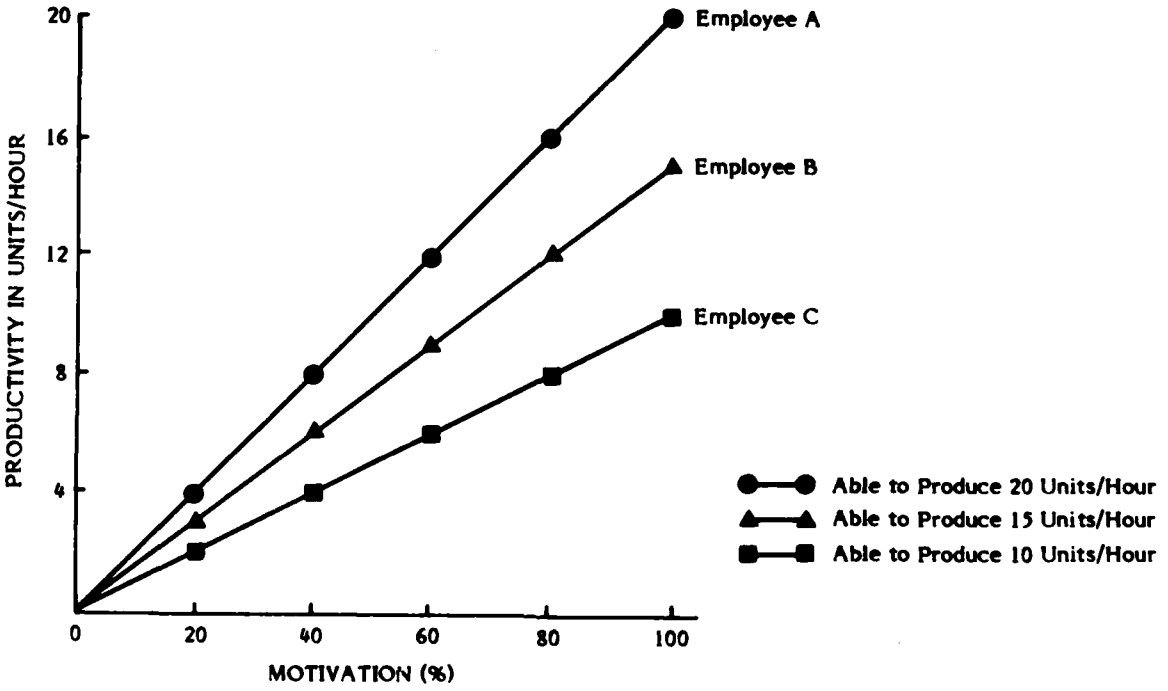


Figure B-3. Example of how ability and motivation determine productivity.

The second implication concerns what happens when new technology is installed in a work group. In such a case, the new technology may be offered as an attractive alternative to improving poor motivation. However, the solution may not be so attractive after all. Return to Figure B-3 again. Suppose the new technology doubled the ability of each employee; that is, employees A, B, C would be able to produce 40, 30, and 20 units per hour respectively. If motivation were not also improved (assume it is 40%), however, the productivity with the new technology would be substantially lower than what would be possible, and probably much lower than what may have been projected to justify the cost of the new technology. This may account for the fact that few technology improvements return the productivity promised. In the example above, if a 12 unit/hour rate of productivity had been projected (assuming 60% motivation) without an increase in motivation, the actual productivity would have been only 8 units/hour (.40 x 20), or a 33 percent shortfall. Perhaps this would be enough to question whether or not the cost of the new technology could be justified. As should be evident from the above discussion, motivation, rather than becoming less important, becomes more important to an organization as new technology is installed.

APPENDIX C

ADJUSTMENT OF WORK HOURS FOR INEXPERIENCED BUYERS

ADJUSTMENT OF WORK HOURS FOR INEXPERIENCED BUYERS

Experience is an important factor in determining productivity. Thus, for a fair comparison of the productivity of the base and trail periods, the experience of the buyers of both periods should be equivalent. This was not the case in the Purchase Division, as one buyer was new during the base period and four were new during the trial period. Therefore, adjustment had to be made for the level of their experience so that the performance of these new buyers of the two periods would be equalized.

Work Hours Correction Factor

A correction factor that adjusted for the buyer's level of experience was determined as follows:

1. The ratio of each new buyer's earned hours to work hours was calculated for each week of experience.

2. Three-week moving averages were calculated for each buyer to smooth out idiosyncratic fluctuations.

3. The moving average group mean was calculated and plotted for each week of experience.

4. A least-squares curve was fit to the plotted data (see Figure C-1).[1] The equation for the curve was found to be:

$$Y = 0.4626\ x^{0.1668} \qquad \text{(C-1)}$$

where

Y = Weeks of experience.

Y = The expected ratio or earned hours to work hours, the expected performance level.

[1]This is a power curve. Through bivariate data transformation where X becomes Log X and Y becomes Log Y, the general power curve expression, $Y = bX^m$, becomes Log $Y = B + m$ Log X. This means that a straight line fit to these data points would have a slope of m and an intercept of b.

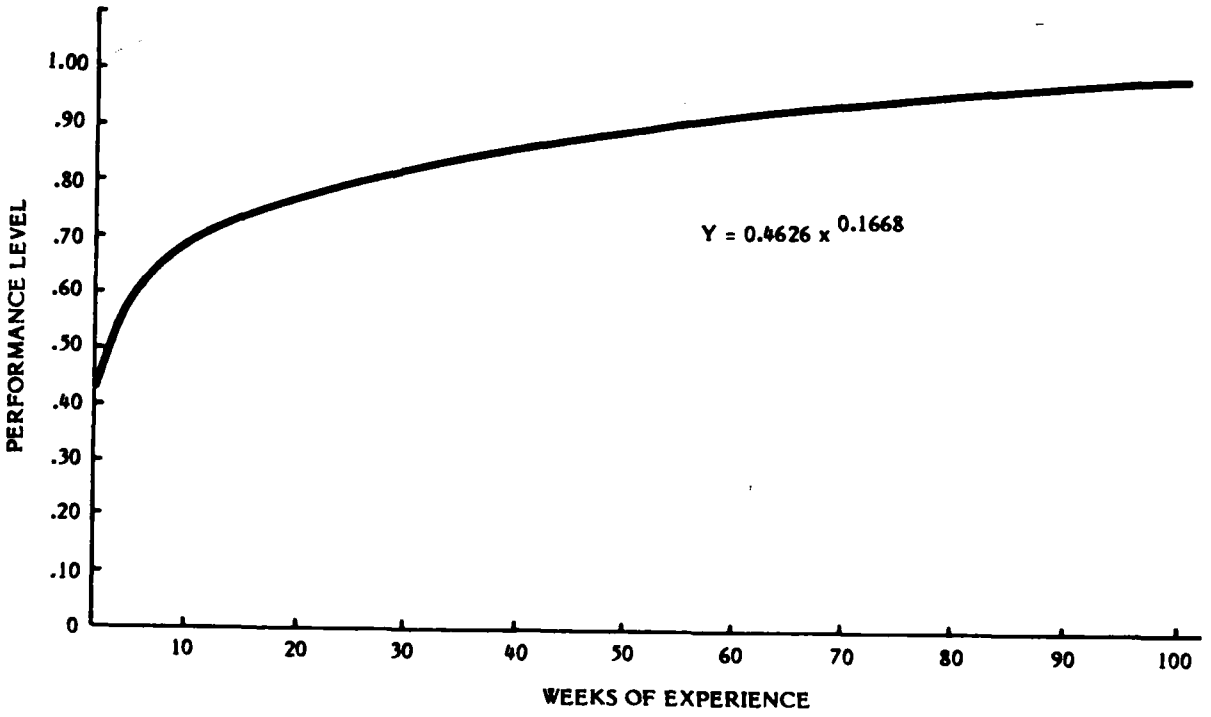


Figure C-1. Power curve relationship between performance level and weeks of experience.

The correlation coefficient (r) between the number of weeks of experience transformed by the power curve and actual performance is 0.823 ($\alpha < 0.005$), which indicates a strong positive relationship.[2] Also, 68 percent ($r^2 = 0.823^2$) of the variance of a buyer's performance level can be accounted for by the buyer's weeks of experience when transformed by this power function. In comparison, the straight line and logarithmic least-squares curve fitting between experience and performance yielded r's of 0.642 and 0.785 respectively.

---

[2]The correlation coefficient (r) is a measure of the degree of the relationship between two variables. The value of r can range from -1.0 to +1.0. The higher the absolute value of r, the stronger the relationship between the two variables. An r of 1.0 indicates a perfect relationship; an r of 0 indicates no relationship. The significance level (α) indicates the probability of an event occurring by chance. Thus, at the $\alpha < 0.005$ level, the probability of a relationship of this strength occurring by chance is less than 1 in 200. Another indicator of the strength of the relationship of two variables is the correlation coefficient squared (r^2), which indicates the proportion of variance that is shared by the two variables. An r^2 of 1.0 indicates that all of the variance is shared by the two variables; that is, 100 percent of the variance of one variable can be accounted for by the other.

This performance curve represents the expected performance levels of buyers based upon experience. It can be seen that, with about 2 years of experience, the expected performance level is 1.00; that is, the buyer's performance level is "up to standard" and is that of a fully proficient buyer. For determining labor hours used, the work hours of those buyers with less than 2 years of experience were adjusted.

Work Hours Adjustment Formula

Based upon the performance curve, the formula for adjusting the work hours for inexperienced buyers is as follows:

$$A = C(W - L) \qquad \text{(C-2)}$$

where

A = Adjusted work hours.

C = The correction factor, the buyer's expected performance level determined from equation C-1.

W = Work hours, the number of hours the buyer could have worked in a given period.

L = Leave hours, the number of hours the buyer was on leave in the given period.

Adjusted Work Hours Computation Example

Suppose Buyer A has 12 weeks of buying experience with the Purchase Division and was on leave 8 hours in a 40-hour week. Using equations C-1 and C-2, C = 0.70, W = 40, and L = 8. The adjustment formula gives the following result:

$$A = C(W - L) = 0.70\ (40 - 8) = 22.4 \text{ hours.}$$

Buyer A's adjusted work hours are 22.4 hours. That is, with 12 weeks of experience, Buyer A completed a certain amount of work in 32 hours. When that buyer becomes fully qualified, it is expected that the same amount of work will be completed in 22.4 hours. In this way, work hours were adjusted for each new buyer for each week of the base and trial periods. The new buyer's adjusted work hours, rather than his or her actual work hours, were then used in the data analyses. Thus, the experience levels of the buyers of the base and trial periods were equalized.

APPENDIX D

INSTRUCTIONS FOR ENTRIES ON 424X FORMS

INSTRUCTIONS FOR ENTRIES ON 424X FORMS (CODE 532 ONLY)

Column No.	Title	Explanation
1-3	Trans Code (Mandatory)	Always enter 424
4-6	Est Time Shipped	Enter 3-digit julian date for date of shipment from source.
7-11	Quantity (Actual)	Entry only required if quantity on the JML is changed. Enter ACTUAL quantity.
12-18	Commitment Value	Enter the total commitment value for each JML, rounded to the nearest dollar Enter "00" for no-charge procurements. Modifications: 1. If there is no change in the monetary value of the order, leave blank (field is an optional field). 2. If there is an increase in the order, enter the amount of increase to the nearest dollar. 3. If there is a decrease in the order, enter the amount of decrease to the nearest dollar and bracket the amount. Example: Decrease of $250 shall be entered as (250). Before turning in the 424X Form at the end of the day, total the commitment value column and notate the total at the bottom of the page in the general area of the commitment value column.
19-22	Est Time of Dlvry	Enter 4-digit julian date for expected date

		of arrival at Pearl Harbor Naval Shipyard.
23-24	U/I	Entry only required if unit of issue shown on JML is revised. Enter new unit of issue. Modifications: Entry not required.
25-26	Branch Code (Mandatory)	Enter 32
27-28	Individual Code	Enter your 2-letter code assigned for purposes of inputting information on the fische.
29	Type (Mandatory)	Type of Buy/Action: Of the Many Codes assigned to this field, the codes listed below are the codes that will be used by Code 532 personnel: Code Description P PO (Purchase Order), priced U PO (Purchase Order), unpriced B BPA (Blanket Purchase Agreement) Y Orders under BOA (Priced) Z Orders under BOA (Unpriced) I Imprest Fund F Delivery Orders L L-H/T-M Orders under Indefinite Delivery Contracts M Modification - Purchase Order E Educational/Non-Profit Institutions (Purchase Orders Only) G GSS/FSS O Other Federal Agencies
30	In/Out	Enter 1 (procurement made by Code 530 personnel)
31	Adv/Neg	Only Codes 3 and 4 shall be used by Code 532, as follows: 3 Award made to a small business firm 4 Award made to a large business firm

		Modifications: Entry not required.
32	Competition	Code 1 indicates competition obtained Code 0 indicates a non-competitive procurement. Modifications: Entry not required.
33	QA	Enter one of the following codes to indicate QA requirements: 1 LEVEL I/SUBSAFE/SAM 2 NUCLEAR TARGET 3 NON-TARGET I AND II 0 All others
34-35	Neg Authority	Essentially, all procurements will be under Code 03, however, if a procurement is is set aside for Labor Surplus Area/Small Business/Disaster Area or awarded under the Balance of Payments Program, the applicable codes shall be entered, as follows: 1A Labor Surplus Area or Industry Set Aside 1B Small Business Set Aside 1C Disaster Area Set Aside 1D Balance of Payments Program
36-43	Document No.	Enter each JML number Modification: Enter only 1 JML number applicable under the order.
44-45	Blank	Leave Blank
46	Cut No. (Mandatory)	Enter 0 for all JML's except Shop Stores document Enter 9 for Shop Stores documents
47	Insp Code	Entry not required.
48-49	Shop No.	Entry not required.
50	Use Code	Entry not required.
51-54	No. of Line Items...	Entry not required.

55-67	PIIN (Mandatory)	Enter the PIIN assigned to the procurement. The prefix, N00604, N00311, etc. need not be shown in this field. Sample entries: 79W2564 79M7304 77A05621204 79D1824NQ1A Do not use dashes or leave spaces between numbers/letters.
55-67	PIIN (Mandatory) (Continued)	Modifications: Indicate the modification designation number after the order number; i.e., P1, P2, P3, 01, 02, 03. (Note: The modification number to an order placed under an indefinite delivery contract issued by NSC or this Shipyard is designated as 01, 02, 03, etc.) The 0's between the P and the modification designation number need not be entered.
68	Minority	Enter Code 0 if award is not made to a minority business firm. Enter Code 1 if award is made to a minority business firm. Modifications: Entry not required.
69	Priority	Applicable Codes for Code 532 are as follows: 1 Yellow (Priorities 1 & 2, Bearer, Rat Sheet) 2 Red (Priority 03) 3 Blue (Priorities 4, 5 & 6) 0 All others Walk thru's: Priorities on JML's shall govern. Modifications: Entry not required.
70	Criticality	This code is dependent upon the Code shown in the Criticality (CR) Block on the JML. Codes are as follows:

		1 Criticality Block shows B 2 Criticality Block shows E or F 0 All others Modifications: Entry not required.
71	Except Approval	This block requires an entry by your supervisor under the following circumstances: 1. The time required to complete the procurement exceeds the "window" established for that procurement because of delays which could not be controlled by the buyer. Modifications: Entry not required: Supervisor will make necessary transactions on a separate form.
72-74	Days Bought	Enter the number of days from receipt in Code 530 to award, all days inclusive. Modifications: Entry not required.
75-76	Days in Other Codes	Enter the number of days in other codes (540, 2360, etc.) for technical review/action. Modifications: Entry not required.
77-78	Days to Type	Entry not required.
79-80	Clerks Code	Entry not required.

SPECIAL ENTRIES

Modification to an order involving a new JML:

This will not be considered as a modification. Treat the new JML as a new procurement. All entries shall be made as if the buy is being made on a new order. The Type Code will be code assigned to the type of order being modified.

Examples: If a requirement will be added to a priced purchase order, enter "P" in the Type Column.

If a requirement will be added to a delivery order under a GSA Contract, enter "G" in the Type Column.

All applicable blocks shall be filled in as a new procurement, except that the modification designation number (P1, P2, 01, 02) shall also be entered in the PIIN Column just as it would be shown for a modification.

A sample 424X is attached.

TO CODE 143.2	FROM CODE 532	SIGNATURE	TO MAKE DEBIT/CREDIT ADJUSTMENTS TO COMMITMENT VALUE & QUANTITY 424X	DATE

TRANS CODE	EST TIME SHIPPED	QUANTITY (ACTUAL)	COMMITTMENT VALUE (ACTUAL - $s ONLY)	EST TIME OF DLVRY	U/I	BRANCH CODE	INDIVIDUAL CODE	TYPE	IN/OUT	ADV/NEG	COMPETITION	OA	NEG AUTHORITY	DOCUMENT NO.	BLANK	CUT NO.	INSP CODE	SHOP NO.	USE CODE	NO. OF LINE ITEMS C531	PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER (PIIN)	MINORITY	PRIORITY	CRITICALITY	EXCEPT APPROVAL	DAYS BOUGHT	DAYS IN OTHER CODES	DAYS TO TYPE	CLERKS CODE
M	0	0	0	0	0	M	M	0	0	0	0	0	0	M		M	0	0	0	0	0	0	0	0	0	0	0	0	0
424	165		345	9193		32	CW	P	1	3	0	0	3	91522563		0					19W3692P2	0	2	1		6	0		
424						32			1				3			0													
424	183		905	9203		32	EA	G	1	4	1	0	3	91550712		0					19FA247P1	0	0	0		10	0		
424						32			1				3			0													
424	172		1582	9179		32	FK	F	1	4	1	0	3	91523663		0					19DA034NQ1A01	0	0	0		7	0		
424						32			1				3			0													
424						32			1				3			0													
424						32			1				3			0													
424						32			1				3			0													
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424						32			1				3			0													
424						32			1				3			0													
424						32			1				3			0													
424						32			1				3			0													
424						32			1				3			0													

Example
Notification to order
involving a new [illegible]

COMMITMENT ADJUSTMENT
14ND-SYD-4400/56 (REV 1-77)

MISCELLANEOUS NOTES:

When showing repetitive information in more than 1 column, bracket the columns with the repetitive information; then bring the line down. See below:

If the full page of the 424X Form is not used, draw a horizontal line across the page immediately after your last entry. Be sure that the keypunchers can see the line. Do not blend it in with an existing line on the page.

Do not draw arrows below the horizontal line, which indicates the end of the page for the keypunchers. All arrows shall end at your last entry.

TO MAKE DEBIT/CREDIT ADJUSTMENTS TO COMMITMENT VALUE & QUANTITY

424X

U/I	BRANCH CODE	INDIVIDUAL CODE	TYPE	IN/OUT	ADV/NEG	COMPETITION	OA	NEG AUTHORITY	DOCUMENT NO.	BLANK	CUT NO.	INSP CODE	SHOP NO.	USE CODE	NO. OF LINE ITEMS C531	PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER (PIIN)
0	M	M	0	0	0	0	0	0	M		31	0	0	0	0	0
23 24	25 26	27 28	29	30	31	32	33	34 35	36 37 38 39 40 41 42 43	44 45	46	47	48 49	50	51 52 53 54	55 56 57 58 59 60 61 62 63 64 65 66 67
	3 2	E F P		1	3	0	0	3	9 1 5 2 5 2 0 1		0					7 9 W 1 3 0 9
	3 2			1				3	0 2		0					
	3 2			1				3	0 3		0					
	3 2			1				3	0 4		0					
	3 2			1				3	0 5		0					
	3 2			1				3	0 6		0					
	3 2			1				3	0 7		0					
	3 2			1				3	0 8		0					
	3 2			1				3	0 9		0					
	3 2			1	4	0	0	3	9 1 5 2 0 7 4 3		0					7 9 W 1 4 5 2
	3 2			1	3	1		3	9 1 5 8 8 9 0 1		0					M 7 9 0 7
	3 2	✓	✓	1	✓	0	✓	3	9 0 7 9 5 6 7 8		0					✓ W 1 4 5 3
	3 2			1				3			0					
	3 2			1				3			0					

INSTRUCTIONS FOR ENTRIES ON 424X FORMS

Column No.	Title	Explanation
1-3	Trans Code (Mandatory)	Always enter 424
4-6	Est Time Shipped	Leave Blank
7-11	Quantity (Actual)	Leave Blank
12-18	Commitment Value	Leave Blank
19-22	Est Time of Dlvry	Leave Blank
23-24	U/I	Leave Blank
25-26	Branch Code (Mandatory)	Enter 33*
27-28	Individual Code (Mandatory)	Enter your 2-letter code assigned for purposes of inputting information on fische.
29	Type (Mandatory)	Type of Document: Of the many codes assigned to this field, the codes listed below are the codes that will be used by Code 533 personnel:

Code Description

p (1) PO (Purchase Order); Priced and Unpriced
(2) Orders under BOA; Priced and Unpriced
(3) Delivery Orders;
(4) L-H/T-M Order under Indefinite Contracts;
(5) Educational/Non-Profit Institutions, (PO's only);
(6) GSS/FSS;
(7) Other Federal Agencies;
(8) All types of orders

Q RFQ (Request for Quote)

C Contract

D Initial Indefinite Delivery Contract

		K Contract Form 26 R RFP (Request for Proposal) V IFB (Invitation for Bid) W DD 1149 (RQ) and DD 448 (MIPR) M Modification - PO N Modification - Contract T Tracer X RFQ (Telex) H Correspondence, Msg S RFQ (Resend to new vendor)
30	In/Output	Leave Blank
31	Adv/Neg	Leave Blank
32	Competition	Leave Blank
33	QA	Enter one of the following codes to indicate QA requirements: 1 LEVEL I/SUBSAFE/SAM or equivalent 2 NUCLEAR TARGET 3 NON-TARGET I and II 0 All others
34-35	Neg Auth	Leave Blank
36-43	Document No.	Enter each JML number. For Modifications (N & M) and orders (P) only: Only 1 JML number applicable under the order need be entered. If type is H and no Document No. is available enter 99999999.
44-45	Blank	
46	Cut No. (Mandatory)	Enter 0 for all JML's except Shop Stores documents. Enter 9 for Shop Stores

*When Code 533 personnel buy Rubber Stamps, Safety Glasses and Publications enter 34 and use the procedure outlined for Code 532 personnel.

		documents.
47	Insp Code	Entry not required.
48-49	Shop No.	Entry not required.
50	Use Code	Entry not required.
51-54	No. of Line Items...	Entry not required.
55-67	PIIN (Mandatory)	Enter the PIIN assigned to the procurement. The prefix, N00604, N00311, etc. need not be shown in this field. Sample entries: 79W2564 PCEW9197T2980 79M7304 PCCW9204Q3367 79FA241 PCEATRCEQ7610 79D1824NQ1A 79M8085P1 79BA001 79CA142 79RA010 In the case of correspondence (Type "H") and no PIIN number and no document number, PC to buyer with Julian date: PCFK7194. If no PIIN assigned yet. PC to buyer. Modifications: Indicate the modification designation number after the order number, i.e., P1, P2, P3, 01, 02, 03. The o's between the P and the modification designation number need not be entered.
68	Minority	Leave Blank
69	Priority	Leave Blank
70	Criticality	Leave Blank
71	Except Approval	Leave Blank
72-74	Days Bought	Leave Blank
75-76	Days in Other Codes	Leave Blank

77-78	Days to type	Enter number of days it takes to type document
79-80	Clerks Code/ Typewriter	Enter typewriter number: 1 IBM Memory 2 IBM Corrective 3 IBM *Selectric* 4 IBM Standard 5 IBM Mag Card

APPENDIX E

INSTRUCTIONS FOR ENTRIES ON PERSONNEL ACTIVITY LOG (PAL)

INSTRUCTIONS FOR ENTRIES ON PERSONNEL ACTIVITY LOG (PAL)

This is a record of the employee's daily distribution of work and hours spent in activities other than what is reported on the 424X forms. The supervisor shall complete the PAL on a daily basis. Each employee's work distribution and time shall be recorded as follows:

Column No.	Title	Explanation
1-2	DY (Mandatory)	Enter day of the month numerical).
3-4	MO (Mandatory)	Enter month (numerical).
5-6	YR (Mandatory)	Enter last 2 digits of the year.
7-8	Branch Code (Mandatory)	Enter respective branch code; i.e., 31 for Code 531, 32 for Code 532, 33 for Code 533, etc.
9-10	Individual (Mandatory	Enter 2-letter code assigned each employee for purposes of inputting information on the fische, usually, the employee's initials.
	JMLs (REG)	For Codes 531 and 532's use. Log in document distribution of regular JMLs in respective columns as follows: (NOTE: Accuracy is important since this information cannot be reported on 424X Form and will be used in calculation Code 530/ individual buyer's weekly backlog report).
11-13	Rec'd	Enter number of regular JMLs the buyer received for that day.
14-16	Xfer In	Enter number of regular JMLs that were transferred to the buyer from another buyer in code 530.

17-19	Xfer Out	Enter number of regular JMLs that were transferred out from the buyer and assigned to another buyer in Code 530.
20-22	Canc	Enter number of regular JMLs that were cancelled by the buyer for any reason; i.e., per planner, UDM material, to SPCC for procurement, etc. These documents are the documents that are cancelled/ transferred to a code outside of Code 530 for appropriate action.
	JMLs (NUC)	For Codes 531 and 532's use. Log in document distribution of nuclear JMLs in respective columns as follows: (NOTE: Accuracy is important since this information cannot be reported on the 424X Form and will be used in calculating Code 530/ individual buyer's weekly backlog report).
23-25	Rec'd	Enter number of nuclear JMLs the buyer received for that day.
26-28	Xfer In	Enter number of nuclear JMLs that were transferred to that buyer from another buyer in Code 530.
29-31	Xfer Out	Enter number of nuclear JMLs that were transferred out from the buyer and assigned to another buyer in Code 530.
32-34	Canc	Enter number of nuclear JMLs that were cancelled by the buyer for any reason; i.e., per planner, UDM Material, to SPCC for procurement, etc. These documents are the documents that are cancelled/

		transferred to a code outside of Code 530 for appropriate action.
	Hours	An accurate account of all hours spent in activities other than what is reported on the 424X Form shall be maintained to the nearest 1/10 of an hour. (IMPORTANT: Both blocks must be filled in. Therefore, if inputting 1/2 hour, enter 05. The 80 will be read by the computer as 8.0 hrs and the 05 as .5 hrs).
35-36	Reg (Mandatory)	Enter the regular hours the employee is required to work in a normal working day. For full-time employees on an 8-hour day, 40-hours per week work schedule, enter 8.0. For a SIS or part-time employee, enter the number of hours required to work in accordance with his/her regular work schedule. (If an employee is schedule to 8 hrs on Mondays & Wednesdays, enter 80 on Mondays & Wednesday's PAL. Enter 00 for days not scheduled to work). **Do not include leave taken or overtime in this column. This will be accounted for in other columns.**
37-38	OT	Enter number of hours worked overtime for that day.
39-40	Trng	Enter training hours (hours of training the employee RECEIVED that day).
41-41	Unn, EEO, IRO	Enter number of hours employee spent with a union representative/other union

		business with an EEO representative/other EEO business, or in IRO for an authorized business visit.
43-44	Stat, File, Rsch	Enter the number of hours the employee devoted to gather statistical/status information, filing, or other types of research, as directed/authorized by the supervisor.
45-56	Imp Fund (For Code 533 only)	Enter the number of hours spent as Imprest Fund Cashier.
47-48	Misc	Enter the number of hours spent in activities other than those noted in Blocks 39-46, as directed/ authorized by the supervisor.
49-50	LV	Enter the number hours of annual leave taken.
51-52	Other Paid LV	Enter the number of hours of leave taken other than annual leave, sick leave or leave without pay; i.e., administrative leave, court leave, leave to donate blood, etc.
53-54	SL	Enter number of hours of sick leave taken by the employee.
55-56	LWOP	Enter the number of hours of leave without pay taken by the employee. If it is not known whether leave requested is LWOP or not, record it as AL.

Corrections to PAL

The PAL report can be corrected very easily by increasing/decreasing the entry requiring correction in a subsequent report. Procedures are as follows:

Complete the PAL for your daily report. Correcting entries shall be entered below your daily report (do not skip vertical lines in the report). Columns 1-10 are mandatory columns and shall be completed as follows:

Column No.	Explanation
1-6	Enter day, month, and year that the incorrect entry was made.
7-8	Enter appropriate Branch Code.
9-10	Enter the Individual Code for the employee whose information requires correction.

After Columns 1-10 have been completed, only the column(s) that require correction shall be completed. Each column shall show the increase/decrease to be applied to the original input. Decrease shall be shown in brackets.

See samples attached.

COMPLETE DAILY PER INDIVIDUAL - ALL NUMERIC - EXCEPT INDIVIDUAL WHICH IS ALPHA

Y	MO	YR	Branch Code	Individual	JMLS (REG) Recd	JMLS (REG) Xfer In	JMLS (REG) Xfer Out	JMLS (REG) Canc	JMLS (NUC) Recd	JMLS (NUC) Xfer In	JMLS (NUC) Xfer Out	JMLS (NUC) Canc	HOURS Reg	HOURS OT	Other Acty Tng	Other Acty Unn EEO IRO	Other Acty Stat File Rsch	Other Acty Imp Fnd	Other Acty Misc	Pay Code AL	Pay Code Other Paid LV	Pay Code SL	Pay Code LWOP
2	3 4	5 6	7 9	9 10	11 12 13	14 15 16	17 18 19	20 21 22	23 24 25	26 27 28	29 30 31	32 33 34	35 36	37 38	39 40	41 42	43 44	45 46	47 48	49 50	51 52 53 54	55 56	57 58 59 60 61 62 63
5	07	79	32	GA	16			3					80										
				EA	9			1					80										
				EC	20			2					80										
				EF									80										
				FK	24								80										
				MM	8		1	5					80										
				EW	9								80										
				CW	8	1							80										
				RC	16								80										
		↓		PK									40										

(Above entries are your regular reporting for the day.)

2	07	79	32	PK	(20)																		

(Above correction example: If on 5 Jul 79 it was discovered that the recorded number of documents distributed to a buyer (PK) on 2 Jul 79 was 20 more than what was actually distributed to that buyer, the 20 shall be subtracted from that buyer's receipts, indicating correction to the 2 Jul 79 PAL.)

2	07	79	32	EF	20																		

(Above correction example: If on 5 Jul 79 it is discovered that the recorded number of documents distributed to a buyer (EF) on 2 Jul 79 was 20 less than what was actually distributed to that buyer, the 20 shall be added to that buyer's receipts, indicating correction to the 2 Jul 79 PAL.)

COMPLETE DAILY PER INDIVIDUAL - ALL NUMERIC - EXCEPT INDIVIDUAL WHICH IS ALPHA

MO	YR	Branch Code	Individual	JMLS (REC) Recd	JMLS (REC) Xfer In	JMLS (REC) Xfer Out	JMLS (REC) Canc	JMLS (NUC) Recd	JMLS (NUC) Xfer In	JMLS (NUC) Xfer Out	JMLS (NUC) Canc	HOURS Reg	HOURS OT	Other Acty Tng	Other Acty Unn EEO IRO	Other Acty Stat File Rsch	Other Acty Imp Fnd	Other Acty Misc	Pay Code AL	Pay Code Other Paid LV	Pay Code SL	Pay Code LWOP
07	79	32	GA	16			3					80										
			EA	9			1					80										
			EL	20			2					80										
			EF									80										
			FK	24		1	5					80										
			MM	8								80										
			EW	9								80										
			CW	8	1							80										
			RC	16								80										
			PK									40										
			(Above entries are your regular reporting for the day.)																			
07	79	32	FK																80			
			(Above correction example: If on 5 Jul 79 it is discovered that 8 hours of annual leave was not reported for annual leave taken on 2 Jul 79 by "FK", the 8 hours shall be entered as annual leave taken, indicating correction to the 2 Jul 79 PAL.)																			
07	79	32	EW																80			
			CW																(80)			
			(Above correction example: If on 5 Jul 79 it is discovered that 8 hours of annual leave was given to the wrong person on 2 Jul 79, the 8 hours shall be added to the proper employee and subtracted from the other, indicating correction to the 2 Jul 79 PAL.)																			

APPENDIX F

ALTERNATIVE FINANCIAL EVALUATION METHODS

ALTERNATIVE FINANCIAL EVALUATION METHODS

Financial and economic analysis (F&EA) normally involves the entire process of planning expenditures for which returns are expected to extend beyond 1 year. The choice of 1 year is arbitrary, of course, but it is a convenient cutoff period for distinguishing between types of expenditures. Proper F&EA is important for the future well being of the organization, whether in the government or private sector.

As was suggested in the report, the purpose of F&EA should be to make decisions that will generate the greatest benefits for the costs incurred. The F&EA process is designed to determine (1) which of several mutually exclusive investments should be selected, and (2) how many projects, in total, should be accepted to achieve the highest benefits for the costs incurred.

Although there are several methods for ranking investment proposals, only three will be briefly discussed here.

1. Payback method--The number of years required to return the original investment or outlay.

2. Net present value (NFV)--Present values of future returns discounted at the appropriate cost of capital (10% for DoD decisions) minus the cost of the investment.

3. Benefit-cost ratio (B/C ratio) profitability index--Measures the present value return per dollar invested.

The latter two methods are more sophisticated than the payback method because they give explicit consideration to the time factor in the value of money. Since, in one way or another, the NPV and B/C ratio discount the organization's cash flows, they are referred to as discounted cash flow (DCF) techniques. Results using these methods, shown in Table F-1, complement the results using NFV found in Table 6 of the text. The NPV method indicates a net present value of over $290K in a 5-year period for the PCRS. The decision-making criterion used to make "accept-reject" decisions is to accept all investments producing a positive NPV when discounted at the cost of capital (in this case 10%). In the case of capital rationing, those projects with the highest NPVs should be accepted.

The B/C ratio was computed to be 3.118 over a 5-year period. The accept-reject criterion is to accept all investment opportunities where the B/C ratio is equal to or greater than 1 and the NPV is equal to or greater than 0. Therefore, the NPV and B/C ratio approaches give the same solution to accept-reject decisions. It is generally considered that a B/C Ratio in excess of 1.5 in the private sector is an outstanding investment opportunity.

Furthermore, as pointed out in Note 2 to Table F-1, the NPV would be in excess of $432K and the B/C Ratio would be 4.01 if an increase of 6 percent per year in labor costs was assumed. The 6 percent figure represents an average annual increase in basic salary costs over the past 8 years. During the past 3 years, the per year labor cost increases have been well in excess of 6 percent.

In addition, the payback period for the PCRS after absorbing all developmental costs is approximately 1 year. DoD currently has a "fast payback" program for projects (particularly equipment, weapons systems, etc.) that promise to return the original investment within a 3-year period.

Table F-1

Alternative Financial Ranking Methods

Item	Cost
1. Net Present Value Analysis	
Present Value of the Savings Annuity	
@$4,242.11 per biweekly period for 5 years[a]	428,344.78
Minus Present Value of the Costs	137,344.78
Total PCRS setup costs over 18 month period[b]	121,631.67
PCRS maintenance cost @161.86/biweekly period/5 yrs[c]	16,343.73
Net Present Value of Savings	290,369.38 = ACCEPT PCRS

2. Benefit-Cost Ratio

$$\frac{\text{Present value of savings}}{\text{Present value of costs}} = \frac{\$428,344.78}{\$137,344.78} = 3.118 = \text{ACCEPT PCRS}$$

Notes.

1. Projections for the periodic savings and costs are based on series-payment intervals, as described in Fabrycky and Thuesen (1974). The interest rate used is 10 percent as prescribed in DODINST 7041.3 (18 October 1972). All projected savings and costs are in net present values (NPV) that reflect present worth of net savings to be received in an annuity stream biweekly over a 5-year period.

2. Assuming a 6 percent increase in labor costs per year over the next 5 years, the NPV would increase to $432,472 and the B/C Ratio would amount to 4.01.

[a]Assumes level of efficiency to remain equal to trial period and constant level of labor costs.

[b]Total PCRS setup costs were $112,093.22.

[c]Maintenance costs were determined at 20 percent of shipyard development costs.

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